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U. S. DEPARTMENT OF AGRICULTURE

BULLETIN

OF THE

MOUNT WEATHER OBSERVATORY

VOLUME III

PREPARED UNDER THE DIRECTION OF

WILLIS L. MOORE, D. Sc., LL. D.

CHIEF U. S. WEATHER BUREAU

WASHINGTON
GOVERNMENT PRINTING OFFICE
1911

STAFF

OF THE

MOUNT WEATHER OBSERVATORY.

WILLIS L. MOORE, *Director.*
ALFRED J. HENRY, *Executive Officer.*
WILLIAM J. HUMPHREYS, *Supervising Physicist.*
CLEVELAND ABBE, *Editor.*

HERBERT J. KIMBALL..................................Solar Radiation Research.
WILLIAM R. BLAIR....................................Upper Air Research.
CHARLES S. WOOD ....Research Observer.
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LEWIS C. ROSS.......................................Assistant Research Observer.
BERTRAM J. SHERRY...................................Assistant Research Observer.
HARRIS A. MARKS ....Assistant Research Observer

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WASHINGTON
U. S. WEATHER BUREAU
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OF THE
MOUNT WEATHER OBSERVATORY.

Vol. 3. Part 1. January, February, March, 1910. CLEVELAND ABBE, Editor. Closed May 9, 1910 Issued July 9, 1910

(1) SOME EFFECTS OF HEAVY PRESSURE ON ARC SPECTRA.[1]

By W. J. HUMPHREYS. (Dated April, 1910.)

The influence of pressures up to 14 atmospheres on arc spectra,[2] as discovered several years ago, indicated that valuable results might be found by examining spectra produced under much greater pressures. At that time higher pressures could not be obtained, but later, with the aid of a grant from the Rumford Committee of the American Academy of Arts and Sciences, and with the liberal support of the Physical Laboratory of the University of Virginia, apparatus was brought together with the view of largely extending these investigations because of their importance in solar physics and other branches of spectroscopic astronomy, and also because of their value in the study of radiation and absorption, of ionization, and of the substance and nature of matter.

It was soon found that a difference of potential of 110 volts, with which the original work was done, will not maintain a constant arc between carbon poles, either pure or mixed with metallic salts, when the surrounding pressure is greater than that which had already been used;

[1] Mr. W. S. Adams of the solar physics observatory on Mount Wilson has recently published in the Astrophysical Journal an important contribution to our knowledge of the sun, which depends largely on the fact that spectrum lines shift their positions with the changes in pressure to which their source is subjected. Much of the basic work on which Mr. Adams relies for his interpretations of solar phenomena was done at Mount Weather, but published by permission and very properly in the Astrophysical Journal.

In compliance with my request the several original articles in that journal have now been woven together into one continuous memoir, and in this slightly modified form are published in this present official BULLETIN, because of the vital importance to the meteorologist of all laws of radiation and absorption.

The blocks for the plate and for figs. 1 and 2 of this article have been kindly loaned by the Astrophysical Journal.—*Editor.*

[2] Humphreys and Mohler, Astrophysical Journal, 3, 114, 1896; Humphreys, ibid., 4, 249, 1896, and 6, 169, 1897.

and that a difference of 220 volts will not maintain a steady arc beyond a pressure of about 25 atmospheres. Higher voltages of course will

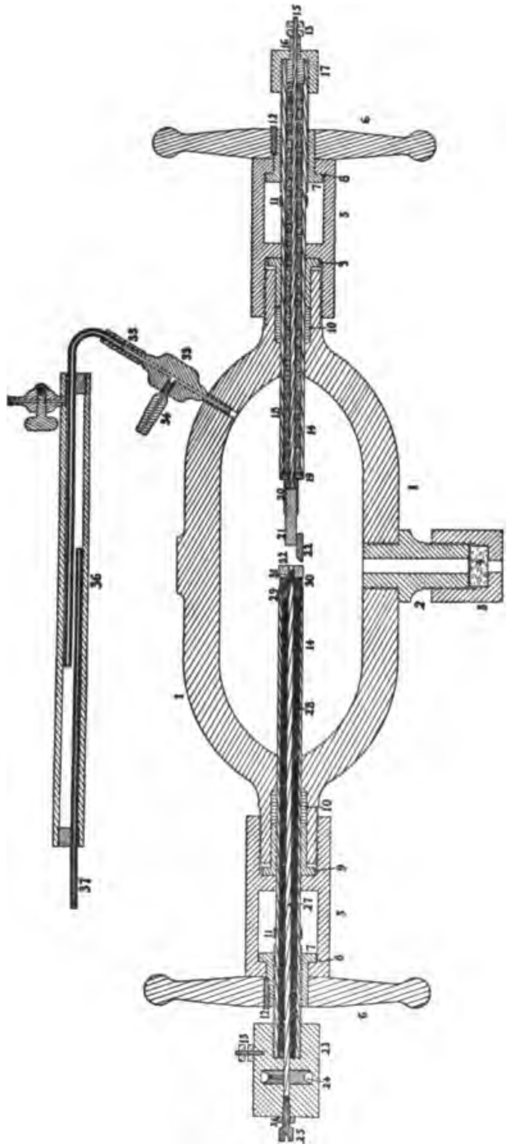

Fig. 1.

produce good arcs under still greater pressures, but they were not available, nor indeed were they desired, since it was necessary to work with

the apparatus in the dark and to take one's chances of getting an occasional shock. A different method, therefore, of obtaining the arc was required, and, after some experimenting, it was found that by making one of the poles in the form of a disk and rotating it, while the other, in the shape of a rod or bar, is brought up so as to touch it at a point some distance from the center—a slight modification of the Crew and Tatnall device—an arc may be maintained with 220 volts between carbons, or between carbon and metal, at any pressure up to and even above 100 atmospheres.

The apparatus that proved efficient for this purpose is shown in section in fig. 1, and mounted as in actual use in fig. 2.

Referring to fig. 1, the large vessel, 1, is a forged cylindrical steel shell 6 inches (15 cm.)in diameter and 16 inches (40 cm.) long, both inside dimensions, with walls 1½ inches (3¾ cm.) thick. A heavy walled block, 2, is screwed into the side of this cylinder and made air-tight. A thick piece of quartz, 4, is held tightly against the end of the tube, 2, by means of the cap, 3. Quartz is used to let ultraviolet radiation through, and besides it has the advantage of being very strong. A thin rubber or leather ring is placed between the quartz block and the end of the tube, 2; and by means of a spanner wrench, the cap, 3, can safely be screwed up till the leak past the packing ring is negligible. It is necessary to cement the quartz block into its seat in the cap, 3, to prevent any trace of leak passing by its outer face. If this is not done and a slight leak occurs—which is reasonably certain to happen—the outer face of the quartz will quickly be covered by moisture, and the beam of light seriously interfered with. That variety of cement known as "Khotinsky, hard" was used. It is easily applied and entirely satisfactory. The ends of the cylinder are drawn out to a proper size, bored in line with each other, and threaded on the outside. Partitioned metal pieces, 5, are fitted to each of these ends, and screwed down with a spanner wrench till their partitions come in contact with the glands, 9, as shown, and force them against the packings, 10, as tight as is necessary to prevent objectionable leakage about the steel tubes, 14, that carry the electrodes.

In assembling the apparatus (in this particular both ends are alike) and before the tube, 14, is introduced, the nut, 7, is placed in the outer chamber of 5, through an opening for that purpose, and slipped forward till shouldered against it at 8. The handwheel, 6, is then fitted on this nut and made fast to it by means of the binding screw, 12. The nut, 7, is large enough to let the smooth part of 14 pass through it, and therefore when the pressure on the packing, 10, is relieved by slightly unscrewing 5, the electrodes may easily be removed from the cylinder; this opera-

tion is frequently necessary and therefore should be made as easy as possible. When in place, as shown, the electrodes are easily adjusted endwise by turning the handwheel, 6, and therefore the nut, 7.

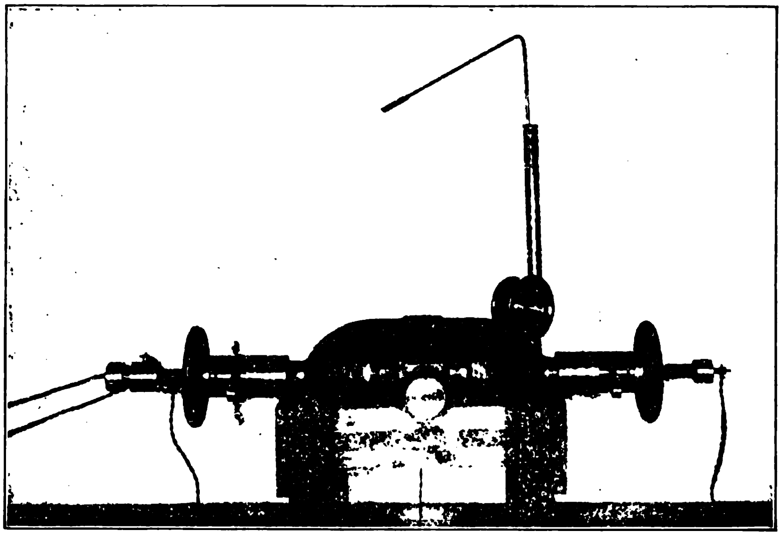

FIG. 2.

A metal rod, 15, provided with a binding post, 13, is screwed through an ebonite block, 16, which in turn is screwed into the tube, 14, and further secured in place by the cap, 17. The inner end of this rod passes through a mica block, 19, against which the thimble, 20, is tightly screwed. This thimble carries the fixed pole, which may be a carbon, or a metallic rod, beveled so as to touch eccentrically the rotating electrode, 32; or it may carry a metal rod, 21, to which the electrode, 22, is made fast by any convenient method. Merely tying them together with copper wire is generally sufficient.

The space between the rod, 15, and the wall of the tube, 14, is filled with powdered or ground mica, 18, which both insulates electrically, and prevents absolutely any air leakage through the tube.

To prevent possible damage to the block of mica, 19, from inequalities of pressure on opposite sides of it, a few small holes were bored very near it through the tube, 14.

The rotating pole, 32, is carried on the end of a small shaft, 27, which is turned by means of a light round belt running from the pulley, 24, to a suitable motor. This shaft passes through a close bearing in the cap, 23, and the end-thrust is taken by a steel ball between the cupped ends

of the shaft and the screw, 25. The inner end of the shaft passes through a loose bearing in the metal block, 29, and is screwed into the thick metal disk, 30. A short rod, 31, is also screwed into the disk, 30, and to its other end is screwed the rotating pole, usually of carbon. The direction of rotation is such that friction against the pole, 22, will tighten the pole, 32. The short rod, 31, is desirable because it is much more easily replaced than the shaft would be, and occasionally it gets badly injured as the rotating disk is burned away. The shaft is adjusted end wise by means of the screw, 25, and when properly placed is made secure with the lock nut, 26.

The space between the rotating shaft and the wall of the tube, 14, that carries it is filled with Ceylon graphite which is micaceous in its structure, and serves to help conduct the current taken in at the binding-post 13, on 23, to the shaft, 27. Besides, it prevents almost absolutely any air leakage through the tube, since any opening tends at once to be filled by graphite which is blown into it; and finally, no matter how tightly packed, the graphite is still a lubricant. Even when the pressure was 101 atmospheres the shaft was rotated with the greatest ease.

A fixed arc may be had, when the pressure is not too high, either by not turning the disk, or by making both poles of the fixed type, in which case there is no occasion to use poles placed eccentrically like 22.

The gas from the compressor enters by means of the tube, 37, into the liquid separator, 36, and thence as shown into the shell containing the arc. The place of admission must be so situated and directed that no moisture shall be blown on to the quartz block, 4, nor the draft strike the arc itself. The first condition is always necessary, and the second desirable in the case of long exposures, since the pump must then be kept running with its blow-off valve set, in order to maintain a constant pressure shown by a gage attached to 34. The pressure is let off by opening the stopcock on the separator, 36, which operation at the same time gets rid of any accumulated liquid.

In use the length of the shell is placed at right angles to the length of the slit of the spectroscope; and the separator, 36, of course stands vertical.

It might seem that there would be trouble in seeing the poles, and therefore in properly adjusting them; but this is easily done by means of an incandescent electric light and an ophthalmoscope mirror. In making such adjustments it is most convenient to have the cap, 3, removed.

It is desirable when making the end-wise adjustments of the poles that the fixed one at least shall not rotate as a result of turning the nut, 7. This trouble, though in practise it seldom happened, can be prevented by

a clamp shown at 11, the outer end of which presses against the edge of the opening in 5.

The apparatus may seem not entirely simple, but there were many conditions to be met, and as constructed it gave such satisfactory results that the labor of making it was amply justified. The only part difficult to obtain was the forged steel shell, but this was finally furnished in an excellent condition by the Janney Steinmetz Company of Philadelphia.

With this specially constructed apparatus I secured, during the spring of 1906, nearly 200 spectrogram negatives, each 20 inches (50 cm.) long, taken at pressures of 42, 69, and 101 atmospheres; and to these some 20 supplementary ones were added about a year later.

More than 100 of these spectrograms have been selected and studied, only those being used that were taken when all parts of the apparatus were in careful adjustment, that had lines satisfactorily measurable, and that were above suspicion of accidental displacements during exposure.

A Rowland concave grating of 14,438 lines per inch (568 per mm.) and 21.5 feet (6.5 m.) focal length was used, and nearly all the negatives were taken in the second and third order spectra. The pressures were obtained by forcing air with a four-stage Norwalk compressor into a forged-steel bottle that contained the arc, and read by Crosby gages, afterwards tested by the Bureau of Standards and found to be substantially correct.

During each exposure the pressure was maintained practically constant by having the space about the arc in open communication, through a steel tube, with the compressor which was kept running with its blow-off valve properly set. The pump, which ran very smoothly, and the spectroscope were both located on basement floors, but in different rooms, and so far separated, about 50 feet (15 m.), that no disturbance of the spectrum lines could be detected, though it was carefully searched for both visually and photographically. This freedom from disturbance probably was due in part to the fact that neither instrument was mounted on ground piers, and that there was nowhere any solid connection between them.

The adjustments of a concave grating spectrograph when mounted on tracks at right angles to each other, as used by Rowland and as adopted in the present case, are so well known that ordinarily no description is called for; but in studying displacements or shifts of spectrum lines particular attention must be given to placing the slit rigidly parallel to the rulings on the grating. When this adjustment is not accurately made, a difference in position of the image of the arc on the slit, which often

occurs, will produce a displacement of the lines that may be most misleading.

If one has command of sunlight, it is easy properly to set the slit by observing a sharp line and having an assistant operate the slit till the line becomes narrowest and best defined. Arc spectra, too, may similarly be used, though ordinarily not so satisfactorily, owing to the relatively feeble light in the case of very narrow lines. It is also possible to take a series of negatives with the slit in different but known positions, and from these to determine its proper position. Again, by eclipsing the middle part of the slit, taking the light through only its ends, and adjusting it till the two lines thus produced become continuous with each other, an excellent setting may be secured. Finally, if the tracks along which the grating and camera move are horizontal, one can use a silk or other fiber with a weight attached to it—a plumb line—very close to the end of the ruling on the grating, and adjust the grating until its ruling is quite accurately vertical. The plumb line can then be placed close to the slit and the latter also easily brought to a vertical position, and therefore parallel to the rulings on the grating.

In my own work, not having access to sunlight, I finally adopted this latter method, but checked it up with all the others.

This particular adjustment is described in detail because in studying changes in wave-length it is vital, so much so that an approximation to parallelism quite sufficient for many purposes may in this case lead to serious errors.

The arc was produced by a 220-volt direct current, usually of about 15 amperes, and, as explained above, one of the poles was fixed while the other rotated. This latter was always the anode, and in nearly all cases consisted of carbon. The fixed pole was either carbon or a metal rod, depending on the element under examination. Commercial arc-light carbons, with iron, titanium, calcium, aluminum, and a few other impurities, gave good results, as did also such carbons after being soaked in salts of certain elements. Excellent results were likewise obtained with rods or blocks of iron, chrome iron, self-hardening steel (iron, chromium, manganese), brass, copper, aluminum, and nickel.

The photographic plates employed were the Seed "Gilt Edge" and the Cramer "Isochromatic Instantaneous," the former for much the greater part of the work—all except that done in the green, where the latter kind is more sensitive.

The negatives were obtained in the well-known way of exposing a narrow strip along the middle of the plate, with the sides protected, to the arc under pressure; and then with this part protected exposing the sides of the plate to the arc at atmospheric pressure.

One of the most important effects of pressure on a spectrum line is the shifting of the maximum of its intensity toward the red, an increase of its wave-length, or an increase in the period of vibration of the luminous particle, and much care has been given to its quantitative determination.

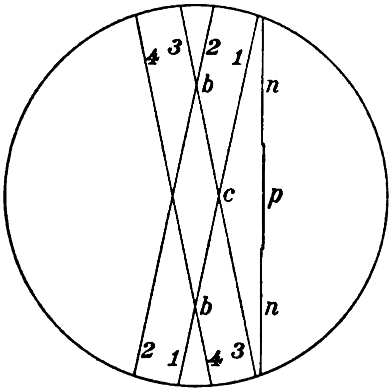

FIG. 3.

The method of measuring this shift is shown by fig. 3, in which 1, 1 and 2, 2 are a pair of parallel spider lines crossed at a sharp angle by an additional pair 3, 3 and 4, 4 in the field of an adjustable low power microscope.

Let *n*, *n* be the portions of a spectrum line taken in the open air, and *p* the displaced portion of the same line taken under pressure. The object is to determine the displacement of *p* from alignment with *n*, *n*; and to do this the microscope, or the spectrum negative, is moved till the intersection *c* of 1, 1 and 3, 3 rests on the densest portion of *p*, when a reading, say R, is taken. It is then moved forward again till the intersections *b*, *b* rest on *n*, *n* when another reading, $K=R+a-x$, is taken, in which x is the displacement required, and a the difference in the two readings when there is no displacement. In this way all the other lines on the negative are measured and the readings recorded. The negative is then turned end for end and the same process repeated. For the line under consideration the second readings become R' and $K'=R'+a+x$.

Now let D be the difference between the first pair, and D' the difference between the second pair of readings, that is,

$$D=K-R=a-x, \text{ and } D'=K'-R'=a+x.$$

Then $x=\dfrac{D'-D}{2}$.

By this method each line is twice measured, and is approached first from the one side and then from the other, a process that has the additional advantage of avoiding possible bias in setting.

To express the displacement in Ångström units it is only necessary to multiply x by a number determined by the order of the spectrum and the constants of the grating—a number easily found by measuring the distance between known lines on the negative.

The measuring machine used was furnished by Gaertner & Co., of Chicago. The screw has a millimeter pitch and reads directly to thousandths of a millimeter. The accuracy of the screw was not directly tested, but in identifying lines the wave-lengths computed from measurements agreed very closely with those given in the best tables, and I am confident therefore that such irregularities of the screw as may exist are well within the errors of measurement, except possibly in the case of very narrow or finely reversed lines—such as one never gets under heavy pressure.

Table 1 gives the lines examined, the pressures under which they were taken, and their corresponding shifts in thousandths of an Ångström unit. Many of these lines were found on a number of different negatives, but they were carefully measured—violet to red and then red to violet—on each negative and the general average taken of all results for any given line and pressure.

The wave-lengths used for aluminum, barium, calcium, copper, iron, lead, magnesium, potassium, strontium, and zinc are taken from tables given by Kayser and Runge; those for chromium, cobalt, manganese, nickel (in part), and titanium (in part), from Hasselberg's tables; and those for lanthanum, nickel (in part), palladium, silicon, titanium (in part), and tungsten, from tables by Exner and Haschek.

TABLE 1.—*Pressure shift.*

λ	At 42 atmospheres.	At 69 atmospheres.	At 101 atmospheres.	λ	At 42 atmospheres.	At 69 atmospheres.	At 101 atmospheres.
			ALUMINUM.				
	Å. U.	*Å. U.*	*Å. U.*		*Å. U.*	*Å. U.*	*Å. U.*
3082.27	0.093			3944.16	0.190	0.314	0.372
3092.95	.087			3961.68	.180	.310	.387
			BARIUM.				
3071.71	0.070			4934.24	0.120		
4554.21	.095	0.162	0.210				

TABLE 1.—*Pressure shift*—Continued.

λ	At 42 atmospheres.	At 69 atmospheres.	At 101 atmospheres.	λ	At 42 atmospheres.	At 69 atmospheres.	At 101 atmospheres.
			CALCIUM.				
	Å. U.	Å. U.	Å. U.		Å. U.	Å. U.	Å. U.
3179.45			0.248	4226.91[c]	0.159	0.265	0.398
3933.83[a]	0.065	0.104	.154	4302.68	.085		
3968.63[b]	.080	.136	.203	4318.80	.072		
[a]K, [b]H, [c]g.			CHROMIUM.				
2835.75	0.051			4195.09	0.083		
3120.51	.036			4198.65	.090		
3433.72	.074			4203.71	.031		
3436.31	.058			4204.61	.087		
3578.81	.074	0.142		4208.50	.090		
3593.57	.095	.120		4209.50	.091		
3605.46	.083	.150		4209.90	.048		
3615.76	.050			4221.71	.080		
3632.92	.080			4240.82	.045		
3646.26	.045			4254.49	.056	0.075	0.130
3666.10	.054			4263.28	.064		
3885.35	.060			4274.91	.076	.123	
3894.20	.072			4280.53	.061		
3908.87	.049			4289.87	.087	.130	.218
3916.38	.062			4295.92	.056		
3919.31	.052			4297.91	.061		
3921.20	.076			4301.33	.052		
3926.80	.166			4323.70	.050		
3928.79	.050			4344.66	.057	.085	.128
3941.66	.046			4351.91	.065	.075	
3963.82	.080			4359.78	.066	.110	
3969.89	.063			4363.25	.064		
3976.81	.058		0.160	4371.44	.060	.084	
3984.02	.140			4497.02	.040	.069	
3990.14	.056			4526.65	.080		
3991.26	.070	.125		4535.95	.075		
3992.95	.066			4546.15	.060		
4001.58	.064			4580.22	.040		
4012.63	.080			4600.92	.085		
4022.38	.066			4613.54	.050		
4023.90	.065			4616.28	.053	.089	
4025.14	.061			4626.31	.056		
4026.30	.080			4646.33	.065	.100	
4027.24	.076			4651.44	.095		
4039.21	.067			4652.31	.058	.088	
4048.94	.070			4680.65	.056		
4058.89	.076			4729.89	.129		
4065.84	.120			4730.88	.101		
4067.05	.044			4756.30	.146		
4077.81	.069			4792.61	.183		
4126.67	.040			5204.67	.164		
4171.81	.050			5206.20	.156		
4179.37	.080			5208.58	.092		
4190.32	.058			5247.68	.132		
4191.41	.040			5348.50	.196		
4193.80	.101						
			COBALT.				
3894.21	0.072	0.143		4092.55	0.042		
3995.45	.054	.131	0.150	4118.92		0.094	
3998.04				4121.47	.070	.104	
			COPPER.				
2883.03		0.040		3274.06	0.090	0.230	
2961.25		.052		4242.42		.473	
2997.46		.046		4249.21		.273	
3010.92		.044		4259.63		.387	
3063.50		.041		4378.40		.420	
3073.89		.026		4415.79		.409	
3094.07		.032		4539.98		.459	
3194.17		.047		4587.19		.513	
3247.65	0.090	.145		4704.77		.460	

TABLE 1.—*Pressure shift*—Continued.

λ	At 42 atmospheres.	At 69 atmospheres.	At 101 atmospheres.	λ	At 42 atmospheres.	At 69 atmospheres.	At 101 atmospheres.
IRON.							
	Å. U.	Å. U.	Å. U.		Å. U.	Å. U.	Å. U.
2931.55	0.026			3570.23	0.075	0.141	
2991.78		0.062		3581.32	.063	.133	
3037.54	.052			3585.43	.100	.162	
3047.71	.053			3585.84	.076		
3050.90		.049		3587.10	.072	.127	
3059.19	.063			3603.34	.062		
3067.30		.071		3605.62	.030		
3175.53	.068			3606.83	.059		
3229.19	.013			3608.99	.072	.117	
3233.14	.038			3618.92	.080	.120	
3254.47	.060			3621.61	.068		
3265.73	.091			3622.15	.060		
3271.12	.100	.123		3623.33	.040		
3291.10	.168			3631.62	.090	.143	
3298.25	.050			3638.44	.061		
3306.50	.072			3640.53	.065		
3307.33	.030			3647.99	.090	.135	
3314.86	.120			3649.65	.060		
3323.84	.073			3650.42	.025		
3329.00	.052			3651.61	.065	.105	
3355.27	.064			3659.65	.050	.080	
3366.88	.035			3669.65	.050	.060	
3369.62	.048	.110		3670.20	.047		
3370.87	.060			3676.44	.050	.086	
3380.17	.054			3677.76	.052		
3384.05	.030	.050		3680.03	.062	.067	
3392.37	.036			3683.18	.040		
3392.74	.069	.120		3684.24	.053		
3394.65	.040	.070		3687.58	.090	.120	
3399.39	.045	.074		3689.58	.084		
3401.60	.080			3695.18	.070		
3402.33	.060			3703.68	.086		
3404.41	.055	.076		3704.59	.046		
3407.55	.060	.108		3705.70	.054	.070	
3411.43	.035			3709.37	.095	.140	
3413.22	.056	.088		3716.04	.107		
3414.83	.060	.068		3720.07	.047	.070	0.091
3415.61	.060			3722.69	.050	.064	
3417.92	.058	.097		3724.51	.054		
3418.58	.060	.100		3727.78	.100	.138	
3422.69	.056			3733.46	.050	.080	
3424.36	.052	.090		3735.00	.092	.150	.180
3425.08	.080			3737.27	.040	.065	.093
3427.21	.053	.104		3738.44	.078		
3428.26	.060			3743.58		.155	
3440.69	.050			3745.67	.050	.086	
3441.07	.050			3745.95	.050		
3443.96	.045	.066		3748.39	.040	.063	.090
3445.22	.054			3749.61	.085	.160	.180
3447.37	.050			3752.57	.098		
3450.41	.057			3758.36	.090	.140	.184
3451.99	.059			3763.90	.095	.180	.195
3458.39	.111			3765.66	.106		.160
3465.95	.050	.067		3767.31	.118	.160	
3471.40	.040			3788.01	.090	.180	
3475.52	.048	.066		3795.13	.093	.135	
3476.75	.036	.059		3798.65	.085	.170	
3485.42	.065			3799.68	.075	.140	
3490.65	.052	.080		3805.47	.092		
3495.37	.048			3813.12	.058	.101	
3497.20	.050			3815.97	.110	.175	.189
3497.92	.045	.075		3820.56	.125	.172	.200
3506.59	.047			3824.58	.040	.050	.070
3508.58	.095			3826.04	.090	.140	.200
3513.91	.063	.100		3827.96	.102	.150	
3521.36	.085			3834.37	.110	.165	.210
3558.62	.085	.150		3840.58	.098	.165	.237
3565.50	.074	.128		3841.19	.100	.180	

TABLE 1.—*Pressure shift*—Continued.

λ	At 42 atmospheres.	At 69 atmospheres.	At 101 atmospheres.	λ	At 42 Atmospheres.	At 69 Atmospheres.	At 101 atmospheres.
			IRON—*Continued.*				
	Å. U.	*Å. U.*	*Å. U.*		*Å. U.*	*Å. U.*	*Å. U.*
3850.11	0.082	0.173	0.235	4315.21	0.036	0.051	0.097
3856.49	.038	.057	.070	4325.92	.097	.143	.189
3860.03	.042	.071	.105	4337.14	.090	.152	
3865.65	.103	.180		4352.86	.052	.074	
3868.03			.082	4367.68	.060	.100	
3872.61	.108	.151		4369.89	.055	.090	
3878.82		.066		4376.04	.039	.060	
3886.38	.056	.083	.101	4379.36	.101		
3887.17	.073	.130		4383.70	.125	.153	.180
3888.63	.089	.174		4384.82	.130		
3893.47	.072			4404.88	.110	.150	.207
3895.75	.030	.047		4407.80	.180		
3899.80	.036	.067	.070	4408.54	.160		
3903.06	.095	.151	.170	4415.27	.087	.146	.220
3904.00	.056			4422.67	.065	.105	
3906.58	.050			4427.44	.055	.086	
3920.36	.033	.060	.077	4430.74	.190		
3923.00	.032	.060	.070	4442.46	.190		
3928.05	.038	.064	.080	4443.30	.060		
3930.37	.047	.065	.090	4447.85	.180		
3948.87	.050		.115	4454.50	.080		
3950.05	.066		.130	4459.24	.160	.203	.250
3956.77	.036			4461.75	.060		
3969.34	.089	.148		4466.70	.056	.074	
3977.83	.042	.077	.105	4476.20	.072	.120	
3981.87			.150	4482.35	.125		
3984.08	.085			4494.67	.200	.290	
3986.27	.061			4528.78	.172	.250	
3997.49	.048	.076	.087	4531.25	.075		
3998.16	.066			4547.95	.097	.180	
4005.33	.103	.152	.215	4592.75	.110		
4009.80	.040	.075		4603.03	.093	.150	
4014.63	.050	.082		4647.54	.070		
4017.23	.062			4662.09	.067		
4021.96	.037	.073	.108	4691.52	.070		
4045.90	.103	.170	.200	4710.37	.060		
4063.63	.107	.168	.201	4736.91	.085		
4071.79	.092	.178	.260	4762.48	.160		
4107.58	.060	.109	.145	4786.91	.076		
4109.88	.062	.092	.115	4789.74	.080		
4118.62	.085	.110	.190	4859.86	.390		
4132.15	.105	.212		4871.43	.420		
4134.77			.138	4878.33	.400		
4143.96	.116	.198		4919.11	.375		
4156.88		.096	.148	5171.71	.075		
4172.81	.140			5195.03	.080		
4181.85			.170	5269.65	.083		
4184.99	.040	.060	.085	5328.15	.100		
4199.19	.073	.120	.190	5371.62	.095		
4202.15	.071	.130	.173	5397.27	.080		
4219.47	.074	.111	.145	5400.60	.063		
4233.76	.240			5405.91	.100		
4236.09	.274	.435		5429.74	.085		
4245.39	.060			5434.66	.120		
4250.93	.089	.138	.180	5447.05	.095		
4260.64	.246	.399	.540	5455.80	.105		
4271.93	.083	.132	.185	5497.52	.110		
4282.58	.043	.061	.093	5501.61	.095		
4294.26	.084	.130		5506.92	.120		
4307.96	.090	.140	.214	5615.81	.080		
			LANTHANUM.				
3916.16	0.030			4086.86	0.144		
3929.34	.092			4238.55	.098		
3988.69	.076			4269.64	.085		
3995.90	.118			4280.43	.058		
4031.85	.068			4430.09	.051		
4037.26	.064			4570.20	.066		
4043.04	.170						

TABLE 1.—*Pressure shift*—Continued.

λ	At 42 atmospheres.	At 69 atmospheres.	At 101 atmospheres.	λ	At 42 atmospheres.	At 69 atmospheres.	At 101 atmospheres.
				LEAD.			
	Å. U.	Å. U.	Å. U.		Å. U.	Å. U.	Å. U.
3639.71			0.306				
				MAGNESIUM.			
2852.22		0.160	0.190	5183.84	0.275		
				MANGANESE.			
3200.06	0.070			4063.38	0.106		
4018.25	.070	0.120		4083.75	.080		
4030.87	.052	.090	0.150	4266.08		0.084	
4033.18	.050	.091	.112	4451.75	.180		
4034.60	.050	.091		4762.54	.145		
4035.88	.086			4766.58	.158		
4041.49	.068	.103		4783.60	.290		
				NICKEL.			
3002.60			0.107	3566.51	0.091		
3003.73			.103	3571.99	.100		
3012.10			.105	3588.08	.092		
3038.05			.097	3597.84	.102		
3050.88	0.032	0.077	.101	3602.41	.082		
3054.40	.041		.102	3609.44	.072		
3057.72	.050	.090	.127	3610.60	.101		
3101.61	.048			3612.86	.080		
3102.00	.059			3619.52	.065		
3134.26	.060		.122	3624.87	.060		
3233.11	.049		.115	3662.10	.053		
3369.66	.077			3664.24		0.110	
3372.12	.048			3670.57		.088	
3374.35	.029			3674.28		.070	
3380.70	.096			3688.58		.068	
3391.21	.070			3722.63		.111	
3393.10	.063			3736.94		.083	
3414.90	.077			3775.71		.088	
3423.80	.084			3783.67		.058	
3433.71	.094			3807.30		.076	
3437.45	.063			3858.40		.117	
3446.34	.071			3972.31		.075	
3452.98	.062			3973.70		.140	0.176
3458.51	.091			4331.78	.088	.150	.204
3461.78	.067			4401.70			.480
3467.63	.063			4459.21			.625
3469.64	.095			4470.61		.580	
3472.68	.080			4520.20		.120	
3493.10	.081			4592.69	.320	.620	
3501.00	.050			4600.51	.464		
3510.47	.083			4605.15	.280	.600	
3519.90	.075			4648.82	.270	.660	
3524.65	.096			4686.39	.325	.557	
3548.34	.080			4714.59	.274		
3561.91	.063			4756.70	.297		
				PALLADIUM.			
3002.74	0.052			3460.93	0.087		
3028.05	.056			3481.31	.096		
3065.41	.082			3517.08	.058		
3114.19	.066			3634.85	.063		
3142.97	.040			3690.49	.070		
3219.08	.050			3894.33	.098		
3251.89	.085			3958.79	.119		
3259.01	.094			4213.11	.130		
3287.38	.094			4388.80	.290		

TABLE 1.—*Pressure shift*—Continued.

λ	At 42 atmospheres.	At 69 atmospheres.	At 101 atmospheres.	λ	At 42 atmospheres.	At 69 atmospheres.	At 101 atmospheres.
			POTASSIUM.				
	Å. U.	*Å. U.*	*Å. U.*		*Å. U.*	*Å. U.*	*Å. U.*
4044.29	0.504			4047.36	0.480		
			SILICON.				
2881.70	0.080			3905.70	0.184		
			STRONTIUM.				
4077.88	0.070			4607.52	0.170	0.268	
4215.66	.100						
			TITANIUM.				
3186.58	0.121			3989.92	0.049	0.097	0.140
3200.08	.057			3998.77	.047	.078	.130
3234.68	.042			4009.06	.055	.081	
3236.72	.033			4021.98	.038	.064	
3242.15	.035			4286.15	.103		
3253.04	.044			4287.55	.087		
3349.56	.027	0.046		4291.07	.115		
3354.80	.035	.054		4295.91	.100		
3361.41	.037	.077		4300.73	.104		
3370.61	.045			4301.23	.110		
3371.62	.030	.050		4306.07	.104	.150	
3372.91	.034	.067		4318.83	.042		
3378.03	.025			4427.28		.037	
3386.10	.051	.092		4533.42	.176	.270	
3387.97	.030			4534.97	.124	.195	
3461.69	.080			4544.83	.080		
3635.61	.058			4682.08	.077		
3642.82	.053			4691.50	.080		
3653.61	.050			4758.30	.067		
3685.30	.012			4759.44	.092		
3904.95	.073			4841.00	.029		
3921.56	.068			4981.92	.077	.152	
3948.80	.045			4991.24	.135	.212	
3956.45	.030			4999.67	.120	.165	
3958.33	.045			5007.42		.225	
3981.91	.056	.097	.150	5013.45	.056	.100	
			TUNGSTEN.				
3300.97	0.040			4083.13	0.096		
3311.53	.038			4102.85	.036	0.050	0.062
3326.33	.027			4241.62	.086		
3331.84	.047			4244.52	.060		
3361.26	.071			4269.53	.064		
3373.89	.046			4484.37	.030		
3429.72	.077			4610.12	.087		
4008.91		0.060		4660.00	.071		
4015.39	.060			5053.50	.044		
4019.37	.070	.128					
			ZINC.				
3075.99		0.056		3740.12		0.250	0.320
3683.63		.220	0.350	4058.02	0.200	.280	.382

It seems convenient to list some of the more conspicuous effects of pressure on arc spectra, and, whenever necessary, to comment on each separately.

1. The brilliance of the arc becomes much greater as the pressure, if due to atmospheric air, with which all my work was done, is raised. What the effect of wholly inert gases would be, I can not say. Presumably this is caused by the more rapid wasting away of the electrodes; possibly because of the increased resistance and shortened arc—a greater concentration of energy and it may be a corresponding increase in temperature—though the effect of pressure on the temperature of the electric arc seems to be an open question.

2. Reversals are decidedly more pronounced and frequent under heavy than under light pressures, and especially so in the ultraviolet region. This probably is due to a denser layer of absorbing vapors surrounding the arc, and, like 1, may, in part at least, be accounted for by the more rapid burning of the electrodes.

3. Pressure seems to increase the width of all lines, though quite unequally, and to make them somewhat nebulous, especially at the edges. Occasionally lines are found on certain plates that appear to be narrowed by heavy pressure; but probably this is due to a decrease in exposure, since under these conditions they are rather weak, and therefore only show at their places of maximum intensity.

4. The lines of the carbon (cyanogen) bands are not appreciably displaced, if at all, even at the highest pressures used; though, like the individual lines of the elements, they are increased in width.

5. The wave-lengths of all other lines examined increase approximately proportional to the increase in pressure up to the highest used, though this increase, or shift, is very different, not only for different elements, but even for different lines of the same element.

6. The amount of shift of a given line is practically independent of reversal; that is, the emission and the absorption are similarly and equally affected.

7. In general the pressure shift of the spectrum lines seems to increase with the wave-length, but probably this is true only of lines of the same series; at any rate, it is not conspicuous in the case of iron, nickel, and other elements whose lines appear to belong to many series, or to none.

8. So far as I can judge from the scanty numerical data on the Zeeman effect, in general those lines which are strongly separated by a magnetic field are correspondingly largely displaced by pressure; and conversely those, like the lines of bands, that have but little if any Zeeman separation, are but slightly if at all shifted by pressure.

9. The relative intensities of lines at high and low pressures vary exceedingly. In general, the intensity of titanium lines increases with increase of pressure, while iron in this particular behaves most irregularly; some of its lines become more intense as the pressure is increased, while others are diminished, a number entirely disappearing even at 40 atmospheres. Among those that disappear at this pressure are λ 4222.32 4250.28, 4299.42, 4878.33, 5049.94, and 5191.56.

As already explained, the electrodes burn away more rapidly as the pressure is raised, and therefore the increased intensity of the lines might be expected from the greater rate of supply to the arc of the material to which they are due, and possibly, too, in part to the increased potential gradient. But the opposite effect, the enfeebling of many lines, calls for some other explanation. It may be that their emission, too, is increased, but more or less neutralized by a large absorption factor. Just why this should be so, if indeed it is the correct explanation, is not clear; but neither is it obvious why lines in the open arc, for instance, differ so greatly in the phenomena of reversal, that is, in their relative amounts of emission and absorption.

Since sun-spot lines give similar effects,[3] some of them being intensified, while others are enfeebled, I sought to determine whether there was any connection between sun-spot and pressure phenomena. Unfortunately, however, enfeebled sun-spot iron lines are so faint in the arc that they do not show appreciably on my plates. However, λ 5191.56, which vanishes under heavy pressure, is somewhat intensified in sun-spots. So far, then, as the evidence of a single line is worth anything, it would appear that the light in sun-spots does not come from any great depth in the sun's atmosphere—that the spots, whatever their cause, are distinctly surface phenomena. A careful examination of properly selected lines for pressure shift in spots should be of value in this connection.

10. The shift of spectrum lines seems to be chiefly a function of total and not of partial pressure; that is, the displacement of a line does not greatly, if at all, depend upon the amount of material in the arc to which the line in question is due. Kayser, among others, has shown this to be true at atmospheric pressure, and, if true at one pressure, there is no very clear reason why it should not be equally true at others.

It has been claimed,[4] that the shift is a function of partial pressure, but my plates do not justify this conclusion. While it is true that the measurements of different plates do not always closely agree, nevertheless these differences are generally referable to some instrumental dis-

[3] Hale and Adams, Astrophysical Journal, **23**, 11, 1906; Adams, ibid., **24**, 69, 1906.

[4] Huff, Astrophysical Journal, **14**, 41, 1901.

turbance, all lines on the plate being similarly affected, or else apply to lines whose errors of measurement are very large. At any rate, they are such that I do not feel justified in referring them to anything other than mere accident.

11. The increase in wave-length of the spectrum lines is only a small part of that which would be expected if the luminous particles behaved like Hertzian oscillators.

The period of such an oscillator is known to be expressed by the equation

$$T = 2\pi\sqrt{LC},$$

in which T is the period, L the inductance, and C the capacity. With other things equal, C increases directly with the inductive capacity of the dielectric in which the oscillator is placed.

It is also known that in the case of gases $\mu_\lambda - 1 = ad$, where μ_λ is the refractive index for wave-length λ at the density d, and a is a constant; but for all ordinary pressures $\mu_\lambda - 1$ is small, and therefore so too is a.

But since $\mu^2 = K$, the specific inductive capacity, we have $K = (ad+1)^2 = d(a^2d+2a)+1$. Therefore $K-1 = 2ad$ very nearly; that is, K is approximately a linear function of the density. Now, since K for air at ordinary density is about 1.0006, and for air at a pressure of 100 atmospheres roughly 1.06; then, neglecting temperature effects, we might expect, on the assumption that spectrum lines are due to Hertzian oscillators, that the period at 1 atmosphere will be to that at 100 atmospheres as $\sqrt{1.0006}$ is to $\sqrt{1.06}$; or in symbols, that

$$\frac{\lambda_1}{\lambda_{100}} = \frac{\sqrt{1.0006}}{\sqrt{1.06}};$$

and therefore "g," of wave-length 4227 at 1 atmosphere, would become 4350.6 at 100, or be shifted 123.6 Ångström units. But its measured shift for the same conditions is only 0.4 of an Ångström unit, or one three-hundredth of the calculated amount. Besides, lines of the same wave-length should have equal shifts, which is not in accord with experiment. From these facts it seems that the atoms are not Hertzian oscillators, or that the change in inductive capacity does not extend to their interiors. However, see below for a further discussion of the effect of change in inductive capacity.

This same line of argument has been offered by W. B. Anderson,[5] but I venture to discuss it rather fully because the statement in a former paper[6]

[5] Astrophysical Journal, 24, 253, 1906.

[6] Humphreys, ibid., 6, 184, 1897.

that it would not be easy to decide the question experimentally has led to some misunderstanding.

The effects of different gases might be tried on arc spectra, as has been done in an excellent piece of work on spark spectra,[7] but this is already in great measure secured by using metal poles, and carbon poles with metallic impurities; and the difference in the shifts, as already explained, is not decisive. Besides, the difference in the inductive capacities of the gases is a less percentage of the total of either than the error of measurement is of the total shift; and therefore, even if the shift is a linear function of the inductive capacity, it would not be easy to prove it by experiment.

Anderson states that in the case of spark spectra pressure shifts are greater in carbon dioxid than in hydrogen, and gives a table[8] of such lines. This table, all that he gives on the subject, does not appear definitely to prove the above statement. Only four lines admit of comparison, and of these, when reduced to the same pressure, two have greater measured shifts in hydrogen and the other two greater in carbon dioxid.

There is evidence of a typographical error in the data for one of the lines in hydrogen, but, leaving this line out, there is still one line with greater measured shift in hydrogen to two greater in carbon dioxid. Besides, the difference in measurements, when reduced to the same pressure, of a line in carbon dioxid is of the same order of magnitude as the difference between measurements on the same line in carbon dioxid and hydrogen. Finally, from the widths of the reversals, these lines could not be measured with much accuracy.

Therefore, in spite of this excellent paper, the influence of specific inductive capacity on pressure shift does not appear to be well established.

In this connection it is interesting to compare arc and spark shifts,[9] under definite, though unavoidably different, conditions.

Table 2 gives this comparison for a number of iron lines. The first column gives the wave-length; the second, the average of several measurements of shift of spark lines (the inductance being 75 millihenrys and the capacity 0.0270 microfarads), produced in carbon dioxid at 50 atmospheres pressure; the third, the average corresponding shifts, computed for the same pressure from all measurements, of the arc lines produced in air by a direct current of about 15 amperes.

For another plate Anderson gives decidedly greater measured shifts, but in this case the reversals were much wider, and therefore, if I may judge from similar plates of my own, very deceptive, giving larger meas-

[7] W. B. Anderson, ibid., **24**, 221, 1906.

[8] Loc. cit., **24**, 252, 1906.

[9] Anderson, loc. cit., p. 250.

ured shifts than do the same lines produced under the same conditions, but with longer exposures, and therefore narrower reversals. It will be noticed that the general agreement is fairly close, showing that presumably neither the nature of the surrounding gas nor the mode of rendering the atoms luminous changes very greatly the magnitude of the shift. However, in the Publications of the Yerkes Observatory, Volume III, Part II, Plate XXII, Hale and Kent give a comparison between displacements they obtained with high potential discharge in gases and those I obtained with the arc under similar conditions. Five of the lines agree reasonably well, three show much greater displacements when produced by sparks, while one, λ 3606.85, was not formerly measured by myself and is therefore left uncompared.

TABLE 2.—*Shifts, in Angström units, at 50 atmospheres pressure of spark iron lines in carbon dioxid and of the same arc lines in air.*

λ	$\Delta\lambda$		λ	$\Delta\lambda$	
	Spark. Anderson	Arc. Humphreys		Spark. Anderson	Arc. Humphreys
3687.58	0.107	0.096	3865.65	0.075	0.124
3709.37	.119	.106	3969.34	.092	.105
3758.36	.089	.099	3977.83	.075	.053
3763.90	.082	.112	3997.49	.079	.052
3765.66	.097	.102	4021.96	.093	.050
3767.31	.115	.110	4045.90	.106	.114
3805.47	.068	.107	4063.63	.105	.115
3813.12	.074	.070	4071.79	.131	.122
3815.97	.104	.114	4132.15	.107	.136
3824.58	.052	.040	4156.88	.073	.072
3827.96	.126	.113	4199.19	.090	.089
3834.37	.095	.117	4219.47	.097	.080
3856.49	.055	.040			

The present paper leaves these relations exactly as they were, except that λ 3606.85 has now been measured in the arc under pressure, and gives a disagreement even greater than does any one of the other compared lines, so that the possible difference of pressure shift of arc and spark lines is still an open question.

In regard to the atom and its mode of vibration, the solution of which is one of the great aims of spectroscopic work, it seems that the Zeeman phenomenon demands that, whatever its substance, it shall, in part at least, be electrical; that the spectrum lines are not caused by simple mechanical vibrations of uncharged bodies such as are produced by an elastic solid; while the pressure shift shows that specific inductive capacity has but little, if any, influence on the period of whatever it is to which these lines are due.

Since the displacements due to different pressures of spectrum lines can be measured, it is therefore possible to use these displacements in

turn as measures of pressures even at places where no other method is available, and it may therefore serve to give some idea, among other things, of the depths in the sun at which different spectroscopic phenomena have their origin.

I am painfully aware that this paper does not include as many elements as it should, nor is it as exhaustive of any one as it profitably might be; but it is hoped that together with former papers enough is given to indicate what further work should be undertaken. I trust, too, that others may join in this investigation, since an exhaustive study of the subject will require much labor.

Much remains to be done, both on pressure shift and on the Zeeman phenomenon, before the one-to-one relation between them can be definitely established or disproved. Besides, it is not improbable that a fuller study of pressure phenomena may lead to the discovery of groups and series of lines, either through their relative shifts, the pressures at which they cease to exist as lines, or other pressure effects. It may be possible to study the pressure effects on individual parts of a complex line as shown by the echelon or other powerful analyzer, and undoubtedly such an investigation would be of decided interest.

These, while not all, are among the more obvious pressure investigations I hope to see taken up and pushed to some definite conclusion.

Plate I may be of some interest. In all cases the middle strip was taken at the high pressure and the sides at 1 atmosphere.

I shows in the third order and at 42 atmospheres, H and K, and between them two aluminum lines.

II. Second order, 69 atmospheres, gives g, shows the greatly displaced iron line λ 4260.64, and two iron lines, λ 4250.31 and λ 4299.38, that vanish under pressure.

III. Third order, 101 atmospheres, otherwise same as II.

IV. Second order, 101 atmospheres, ultraviolet iron lines.

This shows that many lines are still fairly good at this high pressure.

As above explained the change in width and the change in wave-length are among the most important effects of pressure on spectrum lines, and the following is an attempt to develop a working hypothesis for the explanation and coordination of these phenomena. It is based on the fact that the spectrum lines of a substance yield the well known Zeeman effect when their source is in a magnetic field.

From this effect it seems quite certain that the luminous atom itself must possess a magnetic field of its own, and therefore affect, in the Zeeman sense, the lines produced by its neighboring atoms, whether of the same or of different elements, and in turn suffer similar effects from them.

The nature and the magnitude of the Zeeman phenomenon indicate that the magnetic fields of the atoms are due to moving electrons of the cathode type; and it is convenient, in discussing this phenomenon, to regard these electrons as revolving in closed orbits. Such a "Saturnian," and therefore magnetic, atom will, when placed in an external magnetic field, produce, as a result of induction, the general Zeeman effect; and it is proposed to show that a number of such atoms, when close together, will, through their mutual inductions, produce the phenomenon of pressure shift, besides materially adding to the width of their spectrum lines.

The experimental discovery of either of these two phenomena, the Zeeman and the pressure shift, might, in my opinion (since I believe them to be essentially the same thing), have led to the prediction of the other. As a matter of fact the more obscure one, the pressure shift, was first discovered, but its explanation in terms of interacting "Saturnian" or magnetic atoms did not suggest itself till a number of years after the independent discovery of the Zeeman effect.

While the effect of a magnetic field on spectrum lines seems to demand the assumption of cathode electrons in some sort of orbital motion, it is necessary, before using this assumption as a working hypothesis, to give it proper limitations, to find a structure meeting these conditions that does not violate known physical laws; and this problem has been solved by J. J. Thomson,[10] who has shown that an atom consisting of negative electrons in a sphere of uniformly distributed positive electricity is stable when the electrons are properly spaced and rapidly rotating in coaxial circular orbits, the axis of rotation passing through the center of the atom, and the number of electrons per orbit increasing with the order of its distance from the center. When undisturbed the angular distance, as seen from a point on the axis, from electron to electron of any given ring is a constant.

Clearly, if the electrons are revolving in circular orbits, each ring will produce its own magnetic field, and therefore the system will possess minimum potential energy when the planes of the rings are parallel and all the electrons are rotating in the same direction. I therefore assume that this is the general distribution and condition of the electrons in an atom. As to the equal amount of positive electricity, it is only necessary that it shall be approximately at rest with reference to the electrons, and so distributed as to secure the stability of the rings. This may be secured, as above explained, by having it uniformly distributed throughout a sphere whose center is on the axis of the rings, and whose radius is equal to or greater than that of the outermost orbit. Possibly the same

[10] Philosophical Magazine (6), 7, 237–265, March, 1904.

result would follow if the positive electricity was uniformly distributed throughout an ellipsoid of revolution whose equatorial plane was parallel to the planes of the orbits. But it is sufficient to know that the ring system of negative electrons is possible.

I assume that the frequency of the electromagnetic or light waves given off by any ring of electrons is either the same as the frequency of its orbital revolution, or else directly dependent thereon. For calculations the former will be used. I assume further that the frequency of this orbital revolution is not appreciably, if at all, a function of the kinetic energy of the atom as a whole—that it is practically free from temperature changes. This may seem to violate certain teachings in the kinetic theory of gases, but practically the same contention has been made by J. J. Thomson,[11] who says:

> If the kinetic energy arising from the motion of the corpuscles relatively to the center of gravity of the atom could by collisions be transformed into kinetic energy due to the motion of the atom as a whole, i. e., into molecular temperature, it would follow from the kinetic theory of gases, since the number of corpuscles in the atom is exceedingly large, that the specific heat of a gas at constant pressure would be very nearly equal to the specific heat at constant volume; whereas, as a matter of fact, in no gas is there any approach to equality in these specific heats. We conclude, therefore, that it is not by collisions that the kinetic energy of the corpuscles is diminished.

In connection with this question see also Magie, "The Partition of Energy," Science, N. S., **23**, 168 et seq. Besides, if it be granted that spectrum lines depend for their origin upon orbital rotations of electrons, and the frequency of these in turn upon the temperature of the gas, then their wave-lengths and the magnitude of the Zeeman effect should be corresponding functions of the temperature; but such a relation does not appear to exist.

Again, probably the magnetism of any metal owes its origin to Ampere currents in the form of permanently rotating rings of electrons. If so, and if the frequency of the orbital revolution be a function of temperature, then we should expect the magnetism to decrease as the temperature is lowered, but no such decrease has ever been found.

The number of electrons in an atom is an important question, but at present a question without a definite answer. Reasons have been given by J. J. Thomson[12] for believing this number to be of the same order as the atomic weight, but he also shows why it appears necessary to assume that a luminous particle possesses many more than the limited number of electrons. On the other hand, it is known that the momentum of a

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[11] Electricity and Matter, pp. 98, 101, 104, and 105.

[12] Phil. Mag., June, 1906.

moving electron is at least partially and probably wholly due to its electrical charge; and up to the present time this is the only known method of accounting for momentum. On this assumption—that momentum is wholly of electrical origin—the number of electrons in the atom appears to be of the order of one thousand times the atomic weight. The number then seems to lie within the limits N and $N \times 10^3$, where N is the atomic weight, and since probably the number of electrons at least in the luminous particle is much greater than N, I shall, to be definite, assume the upper limit $N \times 10^3$. The conclusions reached on this assumption will differ only in magnitude from those based on the assumption of any other definite number.

Consider now some of the mutual actions of this type of atoms upon each other when in a gaseous condition; to be specific, take iron atoms in the electric arc, at atmospheric pressure.

The best available sources give for iron atoms, under the specified conditions, the following data:

Average velocity of each atom as a whole, 10^5 cm. per second.

Charge of each electron, 10^{-20}, in electromagnetic measure.

Charge of each electron, 3×10^{-10}, in electrostatic measure.

Total number of electrons per iron atom 5×10^4, assuming its inertia to be entirely electrical.

Mass of each electron 10^{-27} gram.

Mass of iron atom 5×10^{-23} gram.

Radius of atom, equal to or greater than radius of outer ring of electrons, 10^{-8} cm.

Average distance between centers of atoms, 6×10^{-7} cm.

Assumed number of orbital revolutions per second, inversely proportional to the wave-length; 10^{15} for λ 3000, 5×10^{14} for λ 6000.

This angular velocity does not seem to be at all prohibitively great. The "centrifugal force" on a single electron is equal to $m\omega^2 r$, where m is its mass, ω its angular velocity, and r the radius of its orbit; while the force with which it is drawn by the positive charge toward the center of the atom is equal to $\frac{e^2 5 \times 10^4 r}{a^3}$, where e is the electrostatic charge on each electron, and a the radius of the atom. The ratio of these two forces is independent of the radius of the electron orbit, and, with the attraction for the numerator, is equal to 2×10^7. Consequently the electron rings might have angular velocities of the order assumed, and still be in no danger of flying to pieces.

From the above data it is easy to calculate approximately the magnetic force at the center of the atoms, but to further simplify the work it will be assumed that the several rings of electrons are coplanar and concentric with the atom.

Let i_k be the average current, in absolute electromagnetic measure in the ring K, then $i_k = \frac{Q_k}{t}$, where Q_k is the total quantity of electricity passing any point on the orbit in the time t.

Let ω_k be the constant angular velocity, then $i_k = n_k 10^{-20}\frac{\omega_k}{2\pi}$, where n_k is the number of electrons in the ring K. Let the radius of this ring be r_k, then the magnetic force at its center is

$$H_k = \frac{n_k 10^{-20}\omega_k}{r_k}.$$

Therefore the entire system of orbits gives at the center of the atom a magnetic force

$$\Sigma H_k = \Sigma \frac{n_k 10^{-20}\omega_k}{r_k}.$$

But for λ 6000, $\omega = \pi 10^{15}$, probably somewhat less than the average, though of the same order, while the radius of the outer ring is not greater than 10^{-8} cm., and the radii of the others still less. It therefore would seem conservative to let the average angular velocity be $\pi 10^{15}$, and the average radius 10^{-8} cm. In this case the magnetic force at the center of iron atoms is

$$H = \frac{5\times 10^4 10^{-20}\pi 10^{15}}{10^{-8}} = 5\pi 10^7.$$

According to the above conception of the structure and behavior of atoms, the greater the atomic weight, the greater the strength of the magnetic field, though not necessarily in exactly the same ratio.

It may also be worth while to note that the gyroscopic action of the whirling electrons will tend to cause an atom, when it moves about, to keep its axis always pointing in the same direction, and that the greater the atomic weight, the greater will this tendency be. However, in the turmoil of an electric arc, the direction of an atom's axis is likely to change both rapidly and frequently.

The magnetic fields of such atoms as are here considered are still powerful at appreciable distances from the atoms themselves. Let r be the radius of the orbit, d its distance from a point p on its axis; then the magnetic force at this point, along the axis, is, for iron atoms,

$$H = 5\pi 10^7 \frac{r^3}{d^3}.$$

If the distance is ten times the radius, the force is $5\pi 10^4$, or threefold the most intense field yet obtained by means of an electromagnet. Even at the average distance of the nearest atom, that is, 6×10^{-7} cm.,

$H=730$. Of course, the direction and the magnitude of this force is determinate for any point on or off the axis, but for the purpose of this paper the simple case of points on the axis is sufficient.

With velocities of 10^5 cm. per second each atom will very often approach and leave other atoms. The magnitude of their relative velocities and the angle between the planes of the electron orbits both will vary through wide ranges, but in general at every approach and recession each atom will produce an induced current in the other of greater or less magnitude.

Consider the case of two atoms on a common axis. When their electrons rotate in the same direction, an approach will induce in each atom an electromotive force that will oppose the existing current, and as the atoms recede the induced electromotive force in each will be with the current. If, however, the electrons are rotating in opposite directions, the results will be just the reverse; that is, the induced electromotive force will be with the currents as the atoms approach, and against the currents as they leave each other. In the first case, where the electrons rotate in the same direction, the currents will decrease as the atoms approach, and then increase as they recede, coming finally to their original undisturbed values. In the second case they first increase then decrease till again undisturbed values are reached. In the first case the currents are always less, in the second always greater, than they are in the undisturbed atom.

In the case of an induced current,

$$E=L\frac{di}{dt}+Ri,$$

where E is the induced electromotive force, L the self-induction of the circuit, $\frac{di}{dt}$ the rate of change of the current, R the ohmic resistance of the circuit, and i the strength of the current.

But when, as in the present case, the circuit consists of a single turn, $E=\frac{dN}{dt}$ is the rate of change of the lines of magnetic force inside the circuit. Therefore for the ring K, if its self-induction remains constant, the equation becomes,

$$\frac{dN_k}{dt}=L_k\frac{di_k}{dt}+R_ki_k.$$

But $R_k=0$, since the electrons meet with no ohmic resistance in their orbits; and as the dt on one side of the equation is identical with the dt on other, therefore

$$di_k=\frac{dN_k}{L_k}.$$

Thus the induced current is at all times directly proportional to the total change in the number of magnetic lines of force passing through the circuit. Besides, every induced current persists so long as the new number of lines of magnetic force through the circuit is not allowed to change. In the case of any particular ring K, the value of the current is

$$i_k=\frac{n_k 10^{-20}\omega_k}{2\pi}.$$

Hence

$$di_k=\frac{n_k 10^{-20}d\omega_k}{2\pi}=\frac{dN_k}{L_k},$$

which shows that $\frac{dN_k}{d\omega_k}$ is a constant. Therefore, if the period of a light vibration is the same as the period of orbital rotation of the electrons, or directly dependent upon it, then, whatever the magnitude of the Zeeman effect on a given line, this effect should not be momentary, but should persist invariable so long as the field is unchanged, which, as we know, agrees with the observations.

Again, if the change of the magnetic field does not change the self-induction of the circuit—does not change the radii of the orbits—then the change in ω, the magnitude of the Zeeman effect, should be directly proportional to the strength of the magnetic field, which also is in agreement with observation.

That only the angular velocity, and not the orbital radius, varies when the magnetic field is changed has been demonstrated very cleverly by Langevin.[13] The importance of this proof, I trust, will justify the following slightly modified reproduction of it.

$$M=iA=\frac{ne\omega r\pi r^2}{2\pi r}=\frac{ne\omega r^2}{2}, \tag{1}$$

where M is the moment of the magnetic shell equivalent to the given ring, A its area, i the current, e the charge of a single electron, n the number of electrons in the ring, ω its angular velocity, and r its radius.

Let the external magnetic force, normal to the plane of the electron orbit, be changed at a uniform rate by an amount H. This will inductively change the value of the current by acting tangentially along the ring on each electron with a force Fe, so that the moment of the entire force on the ring becomes $Fner$. But if m is the mass of each electron, then the amount of the total tangential force may be written

$$2mn\frac{d}{dt}\left(\frac{\omega r^2}{}\right).$$

[13] Journal de Physique (4), 4, 678–692, October, 1905.

Therefore

$$Fner = 2mn\frac{d}{dt}\left(\frac{\omega r^2}{2}\right).$$

From (1) $\dfrac{dM}{dt} = ne\dfrac{d}{dt}\left(\dfrac{\omega r^2}{2}\right) = \dfrac{Fne^2r}{2m}$. Hence $dM = ned\left(\dfrac{\omega r^2}{2}\right)$.

But ds on the orbit $= \omega r dt$, and therefore

$$dM = \frac{Fne^2 ds}{2m\omega}.$$

Let δM be the minute change in moment during one orbital revolution. ω will remain practically constant during this short time, and therefore

$$\delta M = -\frac{ne^2}{2m\omega}\int_0^{2\pi r} Fds, \text{ very nearly.}$$

But the integration of an electric force around any closed circuit is equal to the rate of change of the lines of magnetic force in the circuit.

Therefore

$$-\int_0^{2\pi r} Fds = \frac{dHA}{dt} = \frac{\delta HA}{\tau},$$

where δHA is the change in magnetic flux through the circuit during the periodic time τ. Consequently

$$\Delta M = -\frac{ne^2 HA}{2m\omega\tau} = -\frac{ne^2 HA}{4\pi m}.$$

In the case of a mass m rotating uniformly in a circular orbit under a central force $f(r)$, we have, when it is free from external disturbance,

$$f(r) = m\omega^2 r.$$

Now let a magnetic field of intensity H be established normal to the plane of rotation. This will give an added central force $He\omega r$ to each electron. As a result, suppose both r and ω to be slightly changed, giving

$$f(r+\Delta r) = m(\omega+\Delta\omega)^2(r+\Delta r) + He\omega r.$$

Therefore

$$[f'(r) - m\omega^2]\Delta r = 2m\omega r\Delta\omega + He\omega r, \text{ nearly.} \tag{2}$$

As shown above, $dM = ned\left(\frac{\omega r^2}{2}\right)$, or for a single electron

$$\Delta M = e\Delta\left(\frac{\omega r^2}{2}\right) = -\frac{e^2HA}{4\pi m}.$$

But $$A = \pi r^2,$$

hence $$\frac{\Delta\omega r^2}{2} = -\frac{eHr^2}{4m},$$

Also $$\frac{\Delta\omega r^2}{2} = r\omega\Delta r + \frac{r^2\Delta\omega}{2}.$$

Therefore $$-r\omega\Delta r = \frac{r^2\Delta\omega}{2} + \frac{eHr^2}{4m},$$

and $$-4m\omega^2\Delta r = 2m\omega r\Delta\omega + He\omega r. \tag{3}$$

Subtracting (3) from (2), we get

$$[f'(r) + 3m\omega^2]\Delta r = 0;$$

hence either $\Delta r = 0$, or $f'(r) + 3m\omega^2 = 0$.

If $\Delta r = 0$, then from (3) $\Delta\omega = -\frac{He}{2m}$.

If, however, Δr be not zero, then $f'(r) + 3m\omega^2 = 0$, which, combined with $f(r)$, gives $\frac{f'(r)}{f(r)} = -\frac{3}{r}$, and $f(r) = \frac{C}{r^3}$. That is, the only central force that will allow r to change is the improbable one that varies inversely as the cube of the distance. From this it would appear that r almost certainly does not appreciably change as the strength of the magnetic field is varied. If r is constant, it follows that the self-induction is also constant, and the expressions obtained above for the induced currents are justified.

In discussing the motions of atoms among each other, it is necessary to take into consideration not only the effects of temperature, but also the results of their mutual magnetic and electrical attractions and repulsions. But each atom may be regarded as a negative ring with a positive center (center of the positive sphere) of equal amount, and therefore, at distances large with reference to the atomic radius, the resultant electrical force of one atom upon another is practically zero; but with this distance sufficiently decreased, the resultant force (re-

pulsion) is relatively very large. That is, the electrical field of a neutral atom is practically zero everywhere except in the immediate neighborhood of the atom itself.

If u is the velocity of an electron in its ring, then the strength of the magnetic field which it produces at the point r, θ, is $\frac{eu}{r^2}\sin\theta$, and the magnetic attraction between two such moving electrons, provided their velocity does not approach that of light, is $\left(\frac{eu}{r}\right)^2\sin\theta\cos a$, where a is the angle between their directions. But the electrostatic repulsion, under the same conditions, between these electrons is $\left(\frac{e}{r}\right)^2$. In the first case e is in electromagnetic measure, in the second in electrostatic, and the ratio between these is V, the velocity of light. Therefore even in the most favorable case, where $\sin\theta$ and $\cos a$ are both equal to unity, the repulsion is greater than the attraction in the ratio of the square of the velocity of light to the square of the velocity of the electrons. But the velocity of the electrons is roughly $\pi 10^{-8}\,10^{15}$ cm. per second, or one six-hundredth that of light; and consequently, if the rings existed alone, their repulsion would greatly exceed their attraction. However, owing to the structure of the atom, as explained above, the total repulsion probably does not exceed the attraction, under most favorable conditions, except when the atoms are exceedingly close together. Of course, each force produces its own effect, independent of all the others, and therefore may be considered alone.

Take the very special but simple case of two atoms whose electrons are revolving around a common axis, and let the direction of their planes remain fixed, just as the gyroscopic action of the whirling electrons tends to keep them. In this case, whatever the magnitude of the electrostatic action and of the temperature velocity, both will be independent of the direction of the electron rotation. The magnetic force, however, will be attraction when the directions of rotation are the same, and repulsion when they are opposite. It therefore becomes desirable to calculate the approximate velocity the magnetic force can give the atoms during the short time any two can remain sufficiently close together.

As already shown, the force at a point p on the axis distant d from the electron ring is

$$H=\frac{2\pi i r^2}{d^3}=\frac{2\pi i r^2}{(r^2+x^2)^{3/2}},$$

where x is the distance of p from the center of rotation. Let the plane of the second atom pass through p, then, if the field is uniform, the magnetic flux through the second circuit due to the first is

$$\frac{2\pi^2 i r^4}{(r^2+x^2)^{3/2}},$$

and the force between the two circuits is equal to the current in the second multiplied by the differential of the magnetic flux through it with respect to the distance separating them, which gives, when the atoms attract each other,

$$F=2\pi^2 i^2 r^4 \frac{d}{dx}\frac{1}{(r^2+x^2)^{3/2}}=-\frac{6\pi^2 i^2 r^4 x}{(r^2+x^2)^{5/2}}.$$

Applying this equation to the case of two iron atoms, the distance between whose centers is $10r$, we get

$$F=\frac{6\pi^2(25\times10^{-3})^2(10^{-8})^4 10^{-7}}{[(10^{-8})^2+(10^{-7})^2]^{5/2}}=375\times10^{-6}\text{ dyne.}$$

But the mass of an iron atom is 5×10^{-23} gram. Therefore, if one atom is kept stationary and the other allowed to move under the magnetic force at this distance, its acceleration will be 75×10^{17} cm. per second. Now let one atom be stationary and let another pass by it with the average velocity of 10^5 cm. per second. Let the planes of their orbits be parallel and separated, at their nearest approach, by ten times the radius, and suppose the magnetic force to act while a distance of only three times the diameter is passed over. The time required to travel this distance of 6×10^{-8} cm. is 6×10^{-13} seconds, and in this time the velocity generated, due to the magnetic action alone, is 45×10^5 cm. per second, or forty-five times the average temperature velocity. Both atoms will be acted on simultaneously, and hence their relative acceleration will be doubled. It is likely that no such great velocities would be generated under the supposed conditions, because every increase in the velocity will correspondingly decrease the period during which acceleration can take place. However, it is clear that the line-of-sight motion of such atoms will, when they are close together, be greatly different from that due to temperature alone. Besides, they certainly will act inductively upon each other, and with distinctly greater effect when they attract, thus getting into the stronger portions of each other's magnetic fields, than when the reverse is the case.

The relative velocities and orientation of the atoms will vary through wide ranges, but from the conclusions reached in the above discussion it appears that atoms can not easily, if at all, be forced into actual contact, owing to the large electrostatic forces that come into play, and that therefore when they rush close together they will rebound; also that, owing to their powerful magnetic fields, they will pursue paths that bring mutually attracting faces relatively close together, and keep the repelling ones comparatively far apart.

Before leaving the question of the magnetic condition of the luminous atom it may be well to consider it in a manner different from the foregoing, less complete in some particulars, but much simpler and more direct.

Experiment shows that one magnetic field can be acted on by another magnetic field, and no other method of acting on it has been discovered; that a magnetic field always accompanies an electric current, and no other source of magnetism is definitely known; and that a moving electric charge is an electric current. For these reasons it seems certain that the luminous particle, which is influenced by a magnetic field, possesses a magnetic field of its own, due to moving electric charges, negative, as experiment assures us, in their nature. Besides we know that spectrum lines, when produced in a magnetic field, are split up into parts; one portion of the line having a less and another a greater wave-length than that of the undisturbed line. This means that the electrons are moving in such manner that their periods may be increased or decreased owing to the orientation of the atom to the disturbing field, a condition fully met by assigning to them circular or elliptical orbits.

Therefore assume a structure consisting of one or more circular rings of electrons in orbital motion, all rings coplanar and all revolving in the same sense around a common axis. The electrons in any given ring may be temporarily bunched to some extent or otherwise disturbed, but their normal condition will be one of equal angular distribution, and of equal angular velocity, as viewed from a point on the axis. And all these rings will be inductively bound together, so that to change, by means of an external magnetic field, the angular velocity of any one is to change in the same sense, but not necessarily to the same extent, the angular velocity of every other.

For the sake of simplicity consider a single such ring of electrons. It will produce ether vibrations of the wave-length λ determined by the relation

$$\frac{V}{\lambda} = \frac{\omega}{2\pi} = KS. \tag{1}$$

where V is the velocity of light, ω the angular velocity of the electrons, K a constant, and S the average strength of magnetic field enclosed by the orbit and due to the moving electrons. However, whether the wave frequency of the spectrum lines is the same as the frequency of the orbital revolutions of the electrons, or only some multiple or submultiple of it, is immaterial to the argument, as any change in this particular would simply change the value of S. It is only necessary that the wave-length be directly dependent upon this orbital revolution, so that any changes in the period of the revolution will produce proportional changes in the wave-lengths of the lines.

From equation (1) we get

$$-\frac{Vd\lambda}{\lambda^2}=KdS. \tag{2}$$

Therefore, from (1) and (2),

$$-\frac{d\lambda}{\lambda}=\frac{dS}{S}. \tag{3}$$

But dS can be obtained by bringing a magnetic field of strength H to bear on the particle, in which case (3) becomes

$$-\frac{d\lambda}{\lambda}=\frac{H}{S}. \tag{4}$$

By substituting H for dS in (2) we get

$$\frac{d\lambda}{H\lambda^2}=C, \text{ a constant.} \tag{5}$$

But this is the well-known Zeeman law, and therefore it appears quite likely that the assumed ideal particle is closely akin in structure to the actual luminous particle. In general such particles, as the distance between them changes, will be mutually affected inductively, and the extent of this action will be independent of the absolute strength of their magnetic fields; that is, a weak field will affect another equally weak field by the same proportion of itself that two strong ones similarly situated will affect each other. But if their fields are very weak only a nearly symmetrical broadening of the spectrum lines will be produced, since the particles in their movements under the influence of temperature will approach almost equally close together whether they face so as mutually to attract or repel, that is, so as, through induction, to increase or to decrease the orbital period of their electrons. If, however, their magnetic fields are strong the effect will be a broadening, together with a

shift of the maximum intensity to the red, since when attracting, and thus mutually inducing counter currents, they will get distinctly closer together than they will when the reverse is the case. It remains then to find the strength of their fields, and this is easily done by the use of equation (4), in which all the terms except S are directly measurable. By substituting known values for these terms we get $S=45\times 10^7$, approximately, and consequently conclude that the magnetic field of a luminous particle is some thousands of times that of the most powerful electromagnet, and that therefore an unsymmetrical broadening or shift of the order measured is to be expected.

Particles with such strong fields darting about under the influence of temperature would face each other and whirl each other about in a manner analogous to that assumed by Ewing[14] for the molecules of hot iron, and to an extent well nigh independent of the relatively feeble field of any electromagnet. Something, too, of this independence seems to be demanded by the Zeeman effect, since the shifted portions, the increased in wave-length and the decreased, of any spectrum line are of nearly if not quite equal intensity.

From these considerations certain general deductions may be made in regard to spectroscopic phenomena.

I. Only neutral atoms and positive ions—that is, atoms less one or more electrons—can give spectrum lines. The forces acting on these two classes would not be the same, and the lines themselves might therefore radically differ, as Stark[15] has shown them to. Free electrons could be expected to produce only electromagnetic pulses (Roentgen rays) as a result of their more or less sudden accelerations.

II. When a luminous gas is very attenuated, so that any given atom spends much the greater portion of its existence away from the influence of other atoms, then its spectrum lines will be narrowest; such widths as they do have will be due to motion in the line of sight.

Neglecting collisions, we get the approximate result very simply. Let λ be the wave-length when there is no motion, λ_1 its modified value produced by line-of-sight velocity. Then $\lambda-\lambda_1\equiv\delta\lambda=\frac{\lambda v\cos\theta}{V}$, where v is the velocity of the particle (observer stationary), V the velocity of light, θ the angle between the path of the particle and the line of sight and having all values from 0 to π. But $v=k\sqrt{\frac{T}{m}}$, where T is absolute tempera-

[14] Magnetic Induction in Iron and other Metals, p. 334.

[15] Physikalische Zeitschrift, 6, 892, 1905.

ture, m the mass of the luminous particle, and k a constant. Therefore

$$\delta\lambda = \frac{\lambda k \sqrt{T} \cos\theta}{V\sqrt{m}}.$$

That is, the spreading will be:

1. Symmetrical about the point of maximum intensity.
2. Proportional to the wave-length.
3. Proportional to the square root of the absolute temperature directly.
4. Proportional to the square root of the atomic weight inversely.

III. When the density becomes more and more pronounced, a correspondingly increased proportion of the light will be produced while the atoms are close enough together markedly to affect each other. There will then be three causes of broadening:

(*a*) The temperature line-of-sight motion.

(*b*) The line-of-sight motion due to the attractions and repulsions of the atoms—probably in many cases (*b*) exceeds (*a*).

(*c*) The mutually induced currents in the atoms.

Both (*a*) and (*b*) will produce symmetrical broadening, but (*c*), owing to the fact that its effect is greatest when the atoms are arranged so as to attract each other (the atoms then getting much closer together and producing correspondingly greater mutual inductions), will cause unsymmetrical broadening; the bulk of the spreading due to this cause being toward the side of longer wave-length.

Among the spectroscopic phenomena, therefore, which a dense gas may be expected to give are the following:

1. All lines should increase in width when the pressure about their source is increased.
2. With increase of pressure the maxima of all lines should shift toward the red end of the spectrum. (This is a general statement, possible exceptions will be mentioned below.)
3. Ordinarily the spreading of a line should be much greater than its pressure displacement, though with a short exposure it may appear on a negative as a displaced narrow line.
4. Since the intensity of a magnetic field due to a circular current varies inversely as the cube of the distance from it, while the average distance between the molecules of a gas (supposed monatomic in the electric arc) varies directly as the cube root of the pressure, therefore the spreading and the shift both should be roughly linear functions of the pressure. That is, they should increase approximately as the average mutual disturbing influence of the atoms, or as the intensities of those parts of each other's magnetic fields in which they exist.

5. For lines of a given element, similar in their nature, the shifts should be proportional to the wave-length.

6. The spreading and the shifting both should obtain whatever the nature of the surrounding gas, as all atoms present are supposed to be magnetic. The shift, however, should increase as the atomic weight of the surrounding medium is increased—heavier atoms possessing stronger magnetic fields. Experiment leaves this in doubt.

7. The shift of analogous lines due to different elements of the same general nature, elements of the same Mendelejeff group, should increase with increase of atomic weight, since the strength of an atom's magnetic field probably is an increasing function of atomic weight.

8. Any group of lines due to a given element, such as a series, that gives Zeeman effects proportional to the wave-length, should shift under pressure in the same ratio.

9. Ordinarily, lines of large Zeeman effects should show large pressure displacements, while those of small Zeeman effects should be little shifted.

10. Any lines, such as those of band spectra, that do not show the Zeeman effect, should not be displaced.

Every one of the above conclusions is in substantial agreement with experiment, both those applying to the width,[16] and those that refer to the pressure displacement.[17]

Probably all, or nearly all, the phenomena under III would follow from the assumption, which the Zeeman phenomenon appears to justify, that, whatever its structure, a radiating atom produces in its immediate neighborhood a powerful magnetic field—magnetic because it yields to a magnetic field, and powerful because the extent of the yielding is small, the change in wave-length being but a minute fraction of the whole. Therefore the structure assumed at the beginning of this article may not at all agree with real atoms; but such atoms would be magnetic, a property we know luminous atoms to have, and it admits of conception and discussion. Besides, such an atom would behave spectroscopically very much as real atoms do behave, and therefore it may serve the double purpose of coordinating known phenomena, and of suggesting certain others that may be looked for.

It was long ago suggested by Fitzgerald[18] that the increase in the specific inductive capacity of a gas, due to an increase in its density, is

[16] Michelson, Astrophysical Journal, **2**, 251–263, 1895.

[17] Humphreys, ibid., **6**, 169–232, 1897, **26**, 18–35, 1907, et supra.

[18] Astrophysical Journal, **5**, 210, March, 1897.

a *vera causa* for at least a part of the pressure shift of spectrum lines; and very recently Larmor[19] made the same claim, and showed that "if the vibrator operates as a simple Hertzian doublet," then, under certain reasonable assumptions, "the dielectric influence of the neighboring molecules is a *vera causa* of the right order of magnitude."

This theory is very pretty and I trust it will be worked up more completely, because, if true, it must provide for all the pressure effects, while a failure to do so will tend to prove that the vibrator is not of the nature of the simple Hertzian oscillator.

It appears safe to assume that the period of any vibrating body is dependent upon the elasticity both of the body itself and of the surrounding medium that takes up its vibrations, and therefore a change in either of these elasticities will change the period. In all such cases, if the inertia remains constant, we have the equation, $et^2=k$, a constant, where e is the elasticity and t the period. Therefore, in the case of the vibrator that produces a spectrum line, any decrease in e causes a corresponding increase in λ^2. Besides the greater λ the less its increase necessary to produce a given increase in its square.

Consequently if the source of a spectrum line is a kind of a Hertzian doublet, and its pressure shift due to increase in the specific inductive capacity of the surrounding medium, it appears that in general we should expect, among other results due to pressure:

(*a*) A shifting of the entire line to the red.

What we get by experiment is a broadening of the line, both to the violet and to the red, with the latter predominating.

(*b*) The increase of λ^2 to be a linear function of the pressure.

Unfortunately the increase in λ is too small to test this relation.

(*c*) The greater the inductive capacity of the gas used the greater the shift for any given pressure.

This conclusion is not yet established; it demands a knowledge, difficult to obtain, of the inductive capacity of the interior of the arc itself.

(*d*) The greater λ the less its increase.

Experiment does not give any well marked relation between wave-length and pressure shift, but the trend undoubtedly is in the other direction, that is, for the shifts to be greater in the case of lines of longer wave-length.

Possibly these and all other objections can be met by properly distributing, between the interior of the atom itself and the surrounding medium, the elasticity that determines the period of any given line.

[19] Astrophysical Journal, 26, 120, September, 1907.

But this makes the problem a very complex one, and it seems doubtful whether it can ever be made to fit the facts of experiment as well as do magnetically interacting Saturnian atoms.

I fully agree with Larmor that the shift of spectrum lines probably is not strictly a pressure effect, though it increases directly with the pressure of the surrounding gas. But I can not at present agree with him in calling it a density effect, since this would ascribe to heavy atoms an influence directly proportional to their mass, a result by no means experimentally established—in fact the masses of the neighboring atoms seem to be of secondary importance. Possibly the term "proximity effect" might better suit the facts of experiment, as this refers to compactness of numbers, without regard to their individual masses, and therefore, while proportional to pressure, is different from density.

In the Philosophical Magazine for November, 1907, Prof. O. W. Richardson discusses in an excellent manner the pressure shift of spectrum lines, which he attributes to "the effect of sympathetic vibrations occurring in the surrounding atoms." He assumes the spectrum lines to be produced by a vibrating electric doublet within the atom, and from this assumption concludes that the shift due to forced vibrations and their reactions is toward the red, is proportional to the increase in pressure, and, is proportional to the third power of the wave-length. The first two conclusions are in accord with the facts of experiment, but the third is not. The shift is roughly proportional to the first and not to the third power of the wave-length. Neither does this assumption provide a shift of the right magnitude, but one some twenty-five times too great. Presumably then the structure of the atom assumed by Professor Richardson does not very closely coincide with that of the luminous particle to which the spectrum lines are due.

If atoms are assumed to consist in part of rotating rings of electrons, and the spectrum lines to be due to these rotations, then it becomes necessary to show why the rings radiate only under special conditions, and why their energy does not rapidly become dissipated in radiation.

It is assumed that each ring consists of a large number of electrons, symmetrically arranged when undisturbed. In this condition the loss of energy due to radiation, as J. J. Thomson has shown[20] would be exceedingly minute.

If the negative electricity should entirely fill the rings, after the manner suggested by Lord Rayleigh,[21] then, when undisturbed, probably their radiation would be absolutely zero. In either case the loss of

[20] Philosophical Magazine (6), 7, 237, 1904.

[21] Ibid. (6), 11, 117, January, 1906.

energy from radiation, and any restitution of it, from absorption, from flying electrons, or otherwise, might very well be beyond the power of known means for detection.

Let such atoms as these, nonradiating when undisturbed, be hurled violently among each other, as they are at high temperatures. Each will very frequently approach some other closely, and in so doing will cause and suffer inductive effects. In general these disturbances will not be symmetrically distributed about the axis of rotation, and thus greater or less bunchings of the electrons will be produced, and these in their rapid rotation will cause correspondingly powerful electromagnetic radiation—a decreasing radiation with zero for its limit; but, except for disturbances, of constant period, as the deformed rings recover their normal condition. In this way the real energy of radiation is traced back to the energy of the disturbing cause; to the temperature, or kinetic energy of the atoms, and probably in some cases to loose and flying electrons.

Atoms constituted and behaving as here considered would produce radiations corresponding to the period of each ring, and therefore, certainly in the case of elements of the same family, those of greater atomic weight may be expected to furnish the greater number of lines, as they do.

While the number of radiations could not be less than the number of rings, it might be much greater, because of the possibilities for combinations analogous to combination tones in sound; combinations which readily could lead to series of doublets and triplets in which the Zeeman effect would be the same from group to group of lines, but different between the separate lines of each group. And probably, if such lines actually exist, the Zeeman effect, the broadening, and the pressure displacement together may lead to their identification. But whether this should be the result or not, such an investigation would be reasonably sure of valuable discoveries, for the spectroscopic field is a peculiarly rich one.

All the spectrum negatives used in this work, though measured and discussed at Mount Weather, were obtained in the physical laboratory of the University of Virginia, and I wish here to thank President Alderman and Professor Smith for their kindness in placing its excellent equipment at my disposal.

I wish also to thank Dr. Ames for his helpful criticisms of theoretical portions.

(II) FREE AIR DATA FOR JANUARY, FEBRUARY, AND MARCH, 1910.

By the Aerial Section—W. R. BLAIR in charge.

The mean wind velocities for January and March, 26.7 and 26.1 kilometers per hour, respectively, are lower than those of either 1908 or 1909, while that for February, 32.4 kilometers per hour, is higher. The decidedly prevailing wind direction for the period was northwest. On three days, January 16, February 24, and March 1, the surface wind velocity was insufficient to start the kites and no free air observations were made on those days.

The mean of the highest altitudes reached in the 87 flights of the period is 2539 meters above sea level, similar means for the months being 2184, 2702, and 2747 meters, respectively. This mean is somewhat lower than that for these three months in either of the two previous years. The highest flight of the period, 5166 meters above sea level, was made on March 25.

The mean surface temperatures for January and February, −1.7° and −1.5°, are, respectively, 2.3° and 5.0° lower than those of last year, while the March mean, 8.9°, is 6.6° higher than that of last year. The mean daily range of temperature shown in figs. 1, 2, and 3 is less in January and February than in December, 1909, and less than for the same months a year ago. The March range is very large at all three stations, the month being comparatively clear. The record of cloudiness at Mount Weather for the period is as follows:

Month.	Number of days.			Mean cloudiness.
	Clear.	Partly cloudy.	Cloudy.	
January	9	5	17	6.6
February	12	5	11	5.4
March	19	9	3	3.5

The pressure for the period is above the average pressure of these months for the three years past, more decidedly so in March than in January and February. The large range of pressure in January and February gave place to much more uniform pressure in March.

In volume II of the BULLETIN, beginning at pages 26, 80, and 153, may be found some discussion of the occurrence of inversions of temperature and their relation to the passing high and low pressure areas. While this discussion suggests a way of classifying and accounting for many of the inversions observed, it does not account for nearly all,

especially in the winter months. Such inversions of temperature as those of January 9 to 12, Chart I, February 6 and 7, Chart III, or February 23 and 26, Chart IV, are found to accompany a certain type of pressure distribution and occur regardless of the presence of clouds or fog. Others, for example, January 2, 6, 13, 14, etc., are less directly related to pressure distribution and seem to have for their immediate causes the presence of clouds or fog. In the latter class, the highest temperature of the inversion is sometimes observed in the cloud or fog layer, sometimes just above it, for example, January 2 and January 6 and 26 (at the 3500-meter level).

It appears that, in forming clouds, the latent heat of condensation causes an inversion, the maximum temperature of which is in the cloud layer, while in dissipating clouds, the latent heat of vaporization causes an inversion, the base of which is in the cloud layer, and further that, above a heavy layer of stratus or of dense fog, conditions are somewhat as they are at the earth's surface when the sky is cloudless.

To facilitate the study of this type of temperature inversion the clouds through or into which the head kite has carried the meteorograph have been recorded on Charts I to VI, inclusive. A horizontal red line marks the base of the cloud layer at the time of the flight. Its length has no time significance. On this line in red letters is indicated the amount and kind of clouds.

While the presence of clouds usually affects the temperature gradient in the vicinity of the cloud in some way, not necessarily inverting it, there are instances in which no such influence is apparent. From the data furnished by Charts I to VI, it will be easy to add to the examples given above.

The inversions of temperature due to the above causes may be referred to as accidental, since a cloud of comparatively small area may be the cause of one. It is to these accidental inversions that the increased number of inversions observed in the darker winter days is largely due, although the more rapid succession of storms in the winter months increases the number of those that are directly related to the pressure distribution.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Jan. 1.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
11:03 a. m....	719.1	3.2	50	s.	3.6	526	719.1	3.2	50	s.	3.6
12:17 p. m....	718.0	1.6	60	se.	2.7	1146	664.9	1.6	......	wsw.	....
12:25 p. m....	717.8	2.0	50	sse.	3.6	1581	630.1	6.3	......	sw.	....
1:07 p. m....	717.2	2.0	50	sse.	4.9	2138	588.3	4.4	......	sw.	....
1:27 p. m....	717.1	2.5	50	s.	7.2	2760	544.7	0.4	......	sw.	....
1:45 p. m....	716.9	0.5	61	sse.	4.9	3340	506.2	− 2.7	......	sw.	....
2:24 p. m....	716.8	0.2	59	sse.	4.5	2678	550.3	0.5	......	sw.	....
2:52 p. m....	716.9	− 1.7	62	se.	5.4	1877	607.5	5.6	......	sw.	....
3:09 p. m....	716.9	− 2.6	66	se.	6.7	1486	637.1	4.1	......	wsw.	....
3:17 p. m....	716.9	− 2.6	68	se.	6.7	1228	657.5	4.5	......	ssw.	....
3:28 p. m....	716.9	− 2.3	60	se.	7.2	916	683.2	6.4	......	sw.	....
3:40 p. m....	717.0	− 2.7	64	se.	7.2	526	717.0	− 2.7	64	se.	7.2
Jan. 2.											
9:26 a. m....	714.0	11.6	78	wsw.	5.4	526	714.0	11.6	78	wsw.	5.4
9:34 a. m....	714.0	11.4	76	wsw.	5.4	860	686.0	9.9	......	w.	....
9:46 a. m....	714.1	11.6	77	wsw.	5.4	1388	643.6	6.6	......	w.	....
10:02 a. m....	714.1	11.6	76	w.	5.4	1922	602.9	3.6	......	wnw.	....
10:10 a. m....	714.1	11.3	79	w.	5.4	2136	587.4	9.6	......	wnw.	....
10:42 a. m....	713.9	11.0	81	sw.	5.4	2801	541.9	6.7	......	wnw.	....
11:39 a. m....	713.7	12.8	75	w.	5.4	526	713.7	12.8	75	w.	5.4
Jan. 3.											
9:48 a. m....	713.0	15.6	57	wsw.	10.3	526	713.0	15.6	57	wsw.	10.3
9:54 a. m....	713.0	15.5	57	wsw.	8.9	883	683.5	12.6	......	wsw.	....
10:05 a. m....	713.0	15.3	55	wsw.	8.9	1370	644.8	8.5	......	wsw.	....
10:22 a. m....	713.0	15.6	54	wsw.	8.0	1808	611.5	5.2	......	w.	....
10:40 a. m....	712.9	15.7	54	wsw.	8.5	2120	588.6	3.2	......	w.	....
1:07 p. m....	712.6	10.7	80	nw.	7.6	2889	533.8	− 0.3	......	w.	....
2:45 p. m....	712.2	12.4	62	wnw.	14.8	526	712.2	12.4	62	wnw.	14.8

January 1.—Three kites were used; lifting surface, 19.4 sq. m. Wire out, 5000 m.; at maximum altitude, 4900 m.

Ci.-St., A.-St., and A.-Cu., from the west-northwest, covered the sky. A solar halo was visible from 11 a. m. until noon.

Low pressure was central over Lake Superior and high pressure over Florida.

January 2.—Two kites were used; lifting surface, 12.6 sq. m. Wire out, 5000 m., at maximum altitude.

The sky was covered with St.-Cu. from the west-northwest. Their altitude was about 1800 m.

At 8 a. m. high pressure areas were central over Florida and Montana, and a well-developed low was central over the Gulf of St. Lawrence.

January 3—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 7000 m.; at maximum altitude, 5000 m.

There were 4/10 to 9/10 St.-Cu. from the west during the flight, and a few to 2/10 Ci. from the west from 9:57 to 11:10 a. m. The head kite was obscured by clouds from 11:10 a. m. to 1:16 p. m.

Pressure was high over Florida and low over Ontario.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. Jan. 4.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
9:13 a. m....	727.4	−12.1	58	nw.	11.2	526	727.4	−12.1	58	nw.	11.2
9:22 a. m....	727.5	−12.2	61	nw.	13.4	944	687.7	−15.3	......	nw.	....
10:00 a. m....	727.8	−12.0	65	nw.	15.2	1561	635.9	− 4.9	......	nnw.	....
10:50 a. m....	727.8	−11.2	64	nw.	11.6	2531	563.8	0.3	......	nw.	....
10:54 a. m....	727.8	−11.3	67	nw.	12.1	2885	539.5	− 0.7	......	wnw.	....
11:02 a. m....	727.8	−11.0	65	nw.	15.6	2531	563.8	0.0	......	wnw.	....
11:43 a. m....	727.7	−10.6	59	nw.	12.5	1934	607.5	− 1.9	......	nw.	....
11:54 a. m....	727.7	−10.3	59	nw.	10.3	1086	676.5	− 6.2	......	nnw.	....
12:00 m......	727.7	−10.0	60	nw.	11.2	818	700.5	−14.1	......	nw.	....
12:09 p. m....	727.7	−10.2	59	nw.	12.1	526	727.7	−10.2	59	nw.	12.1
Jan. 5.											
8:32 a. m....	726.2	−11.4	90	se.	7.2	526	726.2	−11.4	90	se.	7.2
8:38 a. m....	726.2	−11.4	90	se.	7.2	950	687.4	− 8.1	......	sse.	....
9:05 a. m....	726.0	−11.2	86	se.	8.0	1396	648.9	− 6.6	......	sse.	....
10:30 a. m....	724.8	−11.2	86	se.	8.0	526	724.8	−11.2	86	se.	8.0
Jan. 6.											
1:31 p. m....	711.5	− 2.4	100	nw.	3.1	526	711.5	− 2.4	100	nw.	3.1
1:46 p. m....	711.5	− 1.2	100	nw.	6.3	931	677.1	12.1	......	sw.	....
2:02 p. m....	711.5	− 1.2	100	nw.	5.4	1738	614.1	7.5	......	sw.	....
2:04 p. m....	711.5	− 1.2	100	nw.	5.4	526	711.5	− 1.2	100	nw.	5.4
Jan. 7.											
1:44 p. m....	717.7	− 5.8	69	nw.	14.3	526	717.7	− 5.8	69	nw.	14.3
1:52 p. m....	717.7	− 6.0	64	wnw.	16.5	874	686.4	− 9.1	......	wnw.	....
2:07 p. m....	717.9	− 6.0	62	wnw.	16.5	1324	647.6	−12.0	......	wnw.	....
2:10 p. m....	718.0	− 6.0	64	wnw.	17.0	1430	638.8	− 9.1	......	wnw.	....
2:15 p. m....	718.0	− 6.1	64	wnw.	16.1	1550	629.0	−11.1	......	wnw.	....
2:39 p. m....	718.2	− 6.2	68	wnw.	15.6	1781	610.6	− 8.1	......	wnw.	....
2:58 p. m....	718.3	− 6.4	68	wnw.	17.9	2399	564.4	− 9.3	......	w.	....
3:17 p. m....	718.7	− 6.4	66	wnw.	17.4	2140	583.9	− 8.3	......	w.	....
3:43 p. m....	719.5	− 6.6	63	wnw.	14.8	1502	634.6	− 6.1	......	wnw.	....
4:02 p. m....	719.8	− 7.0	67	wnw.	15.6	1062	671.6	−11.1	......	wnw.	....
4:17 p. m....	720.0	− 7.2	67	wnw.	14.3	526	720.0	− 7.2	67	wnw.	14.3

January 4.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 6000 m., at maximum altitude.

The sky was covered with Ci.-St. from the west-northwest. A solar halo was visible.

Very high pressure, central over the upper Lakes, covered the eastern part of the United States.

January 5.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 5600 m.; at maximum altitude, 2000 m.

There were 10/10 St. from the south-southeast, at an altitude of about 800 m. above sea level.

At 8 a. m. high pressure was central over New England and low pressure over the upper Lakes.

January 6.—One kite was used; lifting surface, 5.4 sq. m. Wire out, 2000 m., at maximum altitude.

Dense fog prevailed throughout the flight. Light rain began at 2:02 p. m.

Pressure was low over Alabama and Tennessee and high off the south Atlantic coast.

January 7.—Three kites were used; lifting surface, 12.4 sq. m. Wire out, 4500 m., at maximum altitude.

There were a few St.-Cu. from the west-northwest.

Low pressure was central over Rhode Island and high over Louisiana.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910. Jan. 8.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
1:56 p.m....	727.9	− 4.2	64	se.	5.8	526	727.9	− 4.2	64	se.	5.8
2:01 p.m...	727.9	− 4.4	63	se.	4.5	691	712.6	− 6.1	......	sse.	....
2:17 p.m...	727.9	− 4.2	61	se.	5.8	950	689.7	− 3.6	......	ssw.	....
2:38 p.m....	727.9	− 4.2	61	se.	5.4	1148	672.5	− 5.0	......	ssw.	....
2:52 p.m....	727.9	− 4.2	61	se.	6.3	1885	612.1	− 7.6	......	sw.	....
3:30 p.m....	727.8	− 4.0	64	se.	6.7	2413	571.9	− 7.8	......	sw.	....
3:42 p.m....	727.8	− 4.1	63	se.	6.3	2657	554.3	− 7.5	......	sw.	....
3:56 p.m....	727.7	− 4.2	64	se.	6.3	3030	528.1	−10.5	......	sw.	....
4:05 p.m....	727.7	− 4.2	64	se.	5.8	2792	544.6	− 8.3	......	sw.	....
4:15 p.m....	727.7	− 4.2	64	se.	5.8	2467	568.0	− 9.5	......	sw.	....
4:22 p.m....	727.7	− 4.4	63	se.	6.3	2017	601.8	− 7.3	......	sw.	....
4:33 p.m....	727.7	− 4.5	65	se.	5.8	1391	651.9	− 5.3	......	sw.	....
4:42 p.m....	727.7	− 4.7	66	se.	6.3	862	697.3	− 3.6	......	s.	....
4:45 p.m....	727.7	− 4.8	68	se.	6.3	732	708.8	− 6.2	......	sse.	....
4:48 p.m....	727.7	− 4.9	69	se.	6.7	526	727.7	− 4.9	69	se.	6.7
Jan. 9.											
8:46 a.m...	723.5	− 6.6	73	wnw.	9.8	526	723.5	− 6.6	73	wnw.	9.8
8:51 a.m....	723.5	− 6.4	73	wnw.	9.4	920	688.2	− 3.9	......	wnw.	....
9:17 a.m....	723.5	− 6.0	74	wnw.	8.0	1352	651.3	− 5.3	......	wnw.	....
9:21 a.m...	723.5	− 6.0	74	wnw.	8.0	1672	625.5	− 3.6	......	wnw.	....
9:36 a.m....	723.5	− 5.6	69	wnw.	8.5	2114	591.4	− 6.3	......	w.	....
10:03 a.m....	723.5	− 4.8	66	wnw.	6.3	2374	572.0	− 7.3	......	w.	....
10:37 a.m....	723.3	− 3.8	64	nw.	6.8	2763	544.0	−10.2	......	wsw.	....
10:50 a.m....	723.2	− 2.9	63	nw.	5.8	2157	587.7	− 7.8	......	w.	....
11:01 a.m....	723.1	− 2.6	60	nw.	4.9	1856	610.7	− 5.2	......	w.	....
11:17 a.m....	723.0	− 2.2	55	nw.	6.3	1348	651.3	− 6.1	......	wnw.	....
11:27 a.m....	723.0	− 1.9	47	wnw.	7.2	917	688.2	− 4.7	......	wnw.	....
11:32 a.m....	722.9	− 1.8	44	wnw.	8.0	526	722.9	− 1.8	44	wnw.	8.0
Jan. 10.											
1:49 p.m....	727.2	− 6.3	52	wnw.	11.6	526	727.2	− 6.3	52	wnw.	11.6
1:54 p.m....	727.2	− 6.5	52	wnw.	12.5	811	701.0	−10.2	......	nw.	....
2:12 p.m....	727.2	− 6.2	52	wnw.	10.7	1015	682.6	−12.4	......	nw.	....
2:32 p.m....	727.2	− 5.9	49	wnw.	10.3	1183	667.8	− 9.2	......	nw.	....
2:46 p.m....	727.2	− 6.1	49	wnw.	11.6	1395	649.7	− 9.2	......	nnw.	....
3:15 p.m....	727.2	− 5.9	49	nw.	9.8	1252	662.2	− 9.2	......	nnw.	....
3:29 p.m....	727.2	− 5.9	46	nw.	9.8	1165	669.6	− 6.7	......	nnw.	....
3:38 p.m....	727.2	− 5.9	46	nw.	8.9	997	684.4	−10.6	......	nw.	....
3:44 p.m....	727.2	− 6.0	49	nw.	10.7	526	727.2	− 6.0	49	nw.	10.7

January 8.—Three kites were used; lifting surface, 19.4 sq. m. Wire out, 4500 m.; at maximum altitude, 4000 m.

The sky was cloudless until 4:27 p. m., when a few Ci.-St. appeared on the northwest horizon.

High pressure was central over Virginia and relatively low pressure was central over Oklahoma.

January 9.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 5000 m.; at maximum altitude, 4000 m.

A few St. were visible near the horizon.

Pressure was high over Iowa and comparatively low over Ontario and off the south Atlantic coast.

January 10.—Two kites were used; lifting surface, 10.8 sq. m. Wire out, 2500 m.; at maximum altitude, 2300 m.

The sky was cloudless.

Pressure was high over Ohio and low off Nova Scotia.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Jan. 11.	mm.	°C.	%		m. p. s.	m.	mm.	°C.	%		m. p. s.
8:22 a. m....	729.3	− 6.7	54	ssw.	4.5	526	729.3	− 6.7	54	ssw.	4.5
9:19 a. m....	729.3	− 4.3	46	sw.	2.7	756	708.5	− 1.5	......	wsw.	....
9:26 a. m....	729.3	− 4.2	45	wsw.	2.7	1358	656.8	0.6	......	wnw.	....
9:37 a. m....	729.3	− 4.3	44	wsw.	3.1	1976	608.1	− 1.2	......	wnw.	....
9:56 a. m....	729.3	− 3.9	47	wsw.	4.9	2592	562.6	− 4.0	......	w.	....
10:32 a. m....	729.2	− 3.7	56	wsw.	4.0	3235	518.4	− 5.4	......	w.	....
11:05 a. m....	729.1	− 4.2	49	wsw.	4.0	2614	560.7	− 3.3	......	w.	....
11:27 a. m....	728.9	− 3.8	53	w.	4.0	1993	606.2	− 1.1	......	wnw.	....
11:40 a. m....	728.8	− 3.4	53	w.	4.0	1414	651.7	− 0.7	......	wnw.	....
11:51 a. m....	728.7	− 3.3	53	w.	3.1	728	710.4	− 1.7	......	wnw.	....
11:59 a. m....	728.6	− 3.1	59	w.	3.1	526	728.6	− 3.1	59	w.	3.1
Jan. 12.											
1:29 p. m....	726.4	5.0	35	w.	4.0	526	726.4	5.0	35	w.	4.0
2:17 p. m....	726.5	4.6	42	w.	4.5	1042	681.8	2.1	......	wnw.	....
3:15 p. m....	726.7	3.3	47	wnw.	5.8	1503	643.4	− 0.8	......	wnw.	....
3:27 p. m....	726.7	2.9	48	nw.	6.7	1016	683.6	1.5	......	nw.	....
3:38 p. m....	726.8	2.0	72	nw.	8.0	806	702.0	− 1.6	......	wnw.	....
3:45 p. m....	726.8	1.7	77	wnw.	11.6	526	726.8	1.7	77	wnw.	11.6
Jan. 13.											
8:29 a. m....	727.5	− 2.5	100	se.	6.3	526	727.5	− 2.5	100	se.	6.3
8:38 a. m....	727.5	− 2.6	100	se.	6.7	774	705.2	− 1.7	......	se.	....
9:34 a. m....	727.5	− 3.0	100	se.	7.6	922	692.1	− 1.3	......	sse.	....
9:39 a. m....	727.5	− 3.0	100	se.	7.2	526	727.5	− 3.0	100	se.	7.2
Jan. 14.											
3:15 p. m....	716.0	− 4.4	100	nw.	7.2	526	716.0	− 4.4	100	nw.	7.2
3:28 p. m....	716.0	− 4.4	100	nnw.	8.0	904	682.7	− 1.5	......	nw.	....
3:48 p. m....	716.0	− 4.6	100	nw.	9.4	1099	666.1	− 2.5	......	nw.	....
4:02 p. m....	716.0	− 4.6	100	nw.	8.9	777	693.7	− 2.0	......	nw.	....
4:08 p. m....	716.0	− 4.6	100	nw.	8.5	526	716.0	− 4.6	100	nw.	8.5

January 11.—Three kites were used; lifting surface, 19.4 sq. m. Wire out, 6000 m., at maximum altitude.

There were 6/10 to 8/10 Ci.-Cu. from the northwest.

At 8 a. m. an extensive high, central over Virginia, covered the Eastern States. High pressure was general.

January 12.—Three kites were used; lifting surface, 19.4 sq. m. Wire out, 2300 m.; at maximum altitude, 1800 m.

The sky was covered with A.-St. until 3 p m., then with St., both from the northwest. Snow began 3:20 p. m.

At 8 a. m. pressure was high over the eastern part of the United States.

January 13.—Three kites were used; lifting surface, 19.4 sq. m. Wire out, 2000 m.; at maximum altitude, 500 m.

Dense fog prevailed. Light snow began 8:35 a. m. and continued during the remainder of the flight.

An active low was central over Illinois. High pressure was central over western Ontario.

January 14.—Two kites were used; lifting surface, 10.8 sq. m. Wire out, 1800 m.; at maximum altitude, 1100 m.

Dense fog prevailed throughout the flight.

Pressure was low over Ohio and high over Quebec.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Jan. 15.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
9:10 a. m....	722.0	− 5.8	......	wnw.	8.5	526	722.0	− 5.8	......	wnw.	8.5
9:13 a. m....	722.1	− 5.6	......	wnw.	8.9	844	694.0	− 4.2	......	nnw.	....
9:38 a. m....	722.5	− 5.1	......	wnw.	10.7	1423	644.6	− 6.0	......	n.	....
10:00 a. m....	722.8	− 4.4	......	wnw.	9.8	1705	622.0	− 8.3	......	n.	....
10:17 a. m....	722.8	− 4.3	......	wnw.	10.7	1845	610.9	− 6.5	......	n.	....
10:59 a. m....	722.7	− 4.1	......	wnw.	12.5	2404	568.6	− 9.8	......	n.	....
11:18 a. m....	722.6	− 3.7	......	wnw.	12.1	2021	597.3	− 7.7	......	n.	....
11:34 a. m....	722.5	− 3.7	......	wnw.	13.0	1360	649.7	− 3.5	......	nnw.	....
11:41 a. m....	722.5	− 3.6	......	wnw.	13.9	1184	664.5	− 6.5	......	nnw.	....
12:01 p. m....	722.4	− 3.4	......	wnw.	11.6	864	692.1	− 5.0	......	nw.	....
12:09 p. m....	722.3	− 3.2	......	nw.	10.7	526	722.3	− 3.2	......	nw.	10.7
Jan. 17.											
4:05 p. m....	716.5	− 0.8	72	se.	3.6	526	716.5	− 0.8	72	se.	3.6
4:11 p. m....	716.5	− 0.6	72	se.	3.6	782	694.2	2.0	......	sw.	....
4:33 p. m....	716.3	− 0.5	71	se.	4.0	1128	664.7	0.3	......	sw.	....
5:00 p. m....	716.2	− 0.5	86	sse.	5.8	526	716.2	− 0.5	86	sse.	5.8
Jan. 18.											
1:21 p. m....	706.1	7.2	92	s.	9.8	526	706.1	7.2	92	s.	9.8
1:27 p. m....	706.0	7.4	92	s.	10.7	850	679.0	10.5	......	sw.	....
1:33 p. m....	705.9	7.4	92	s.	10.7	1144	655.2	9.2	......	sw.	....
2:06 p. m....	705.4	7.8	90	s.	10.7	843	679.0	10.5	......	sw.	....
2:25 p. m....	705.4	8.0	90	s.	8.9	526	705.4	8.0	90	s.	8.9
Jan. 19.											
8:38 a. m....	714.5	− 1.0	57	wnw.	13.4	526	714.5	− 1.0	57	wnw.	13.4
8:43 a. m....	714.6	− 1.0	57	wnw.	10.7	901	681.7	− 3.6	......	wnw.	....
8:54 a. m....	714.8	− 1.0	57	wnw.	10.3	1273	650.3	− 7.1	......	wnw.	....
9:07 a. m....	714.9	− 1.0	61	wnw.	9.8	1516	630.4	− 8.6	......	wnw.	....
9:20 a. m....	715.0	− 1.0	61	wnw.	8.9	1919	598.5	− 9.2	......	wnw.	....
9:38 a. m....	715.2	− 1.0	61	wnw.	12.5	2126	583.1	− 6.6	......	nw.	....
9:41 a. m....	715.2	− 1.0	62	wnw.	12.5	2251	573.8	− 7.6	......	nw.	....
10:06 a. m....	715.3	− 0.5	60	wnw.	13.4	2108	584.9	− 8.5	......	nw.	....
10:17 a. m....	715.4	− 0.4	59	wnw.	13.4	1879	602.3	− 7.8	......	nw.	....
10:27 a. m....	715.5	− 0.4	59	wnw.	11.6	1616	623.1	− 5.9	......	wnw.	....
10:54 a. m....	715.7	− 0.3	59	wnw.	11.6	1418	639.3	− 5.5	......	wnw.	....
10:58 a. m....	715.7	− 0.2	59	wnw.	10.7	1260	652.2	− 6.8	......	wnw.	....
11:05 a. m....	715.8	− 0.2	59	wnw.	9.8	1063	668.9	− 6.0	......	wnw.	....
11:15 a. m....	715.9	0.0	60	wnw.	8.0	830	689.1	− 3.6	......	wnw.	....
11:22 a. m....	715.9	− 0.2	60	wnw.	8.9	526	715.9	− 0.2	60	wnw.	8.9

January 15.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 4900 m.; at maximum altitude, 4100 m.

A.-Cu. from the north-northwest, diminished from 3/10 to few during the flight.

High pressure, central over Lake Huron, covered the eastern part of the United States. Pressure was relatively low off Rhode Island.

January 17.—Two kites were used; lifting surface, 18.0 sq. m. Wire out, 2000 m.; at maximum altitude, 950 m.

The sky was covered with St. from the southwest. Light rain began 4:25 p. m.

At 8 a. m. a ridge of high pressure extended from Florida northeastward to the lower St. Lawrence Valley; lows were central over Lake Superior and Colorado.

January 18.—One kite was used; lifting surface, 5.4 sq. m. Wire out, 1000 m.; at maximum altitude.

There were 10/10 St. from the southwest.

An active low was central over Lake Huron.

January 19.—Three kites were used; lifting surface, 16.2 sq. m. Wire out, 4000 m., at maximum altitude.

There were 6/10 to 8/10 A.-Cu. from the west-southwest and a few St.-Cu. from the northwest.

Pressure was high over Mississippi and low over the Gulf of St. Lawrence.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Jan. 20.	*mm.*	*° C.*	%		*m. p. s.*	*m.*	*mm.*	*° C.*	%		*m. p. s.*
9:15 a. m....	721.0	7.0	38	s.	4.5	526	721.0	7.0	38	s.	4.5
9:39 a. m....	721.0	7.2	38	sse.	4.5	730	703.4	7.8	......	ssw.	....
9:47 a. m....	721.0	7.1	39	s.	4.5	971	683.1	6.0	......	sw.	....
10:05 a. m....	721.0	7.5	39	se.	4.9	1287	657.3	7.1	......	sw.	....
10:34 a. m....	720.7	7.7	36	sse.	5.8	1964	604.8	3.0	......	sw.	....
11:58 a. m....	719.6	7.6	46	se.	5.4	2646	555.5	0.0	......	wsw.	....
12:33 p. m....	719.2	8.2	44	se.	7.2	1956	604.8	4.6	......	sw.	....
12:45 p. m....	719.0	8.0	46	se.	6.7	1383	648.4	7.7	......	ssw.	....
12:59 p. m....	718.8	7.4	49	se.	6.3	993	679.5	10.6	......	s.	....
1:04 p. m....	718.8	7.2	50	se.	6.7	880	688.7	9.1	......	s.	....
1:12 p. m....	718.6	7.0	50	se.	7.2	526	718.6	7.0	50	se.	7.2
Jan. 21.											
3:23 p. m....	699.3	2.9	100	nnw.	6.3	526	699.3	2.9	100	nnw.	6.3
5:36 p. m....	699.7	2.0	93	nw.	10.3	787	677.4	0.1	......	nw.	....
5:39 p. m....	699.7	1.9	91	nw.	10.3	526	699.7	1.9	91	nw.	10.3
Jan. 22.											
9:27 a. m....	700.2	− 4.0	72	wsw.	8.0	526	700.2	− 4.0	72	wsw.	8.0
9:34 a. m....	700.2	− 4.0	72	wsw.	8.0	883	669.0	− 7.6	......	wsw.	....
9:45 a. m....	700.3	− 3.9	68	wsw.	7.6	1277	635.9	−10.7	......	wsw.	....
10:01 a. m....	700.5	− 3.7	66	wsw.	7.6	1370	628.5	− 8.1	......	wsw.	....
10:43 a. m....	700.6	− 3.8	69	wsw.	9.8	1580	611.8	− 9.5	......	wsw.	....
10:55 a. m....	700.6	− 3.8	68	wsw.	8.0	2333	554.7	−13.8	......	sw.	....
11:01 a. m....	700.6	− 3.7	68	wsw.	8.9	2779	522.9	−16.2	......	sw.	....
11:04 a. m....	700.6	− 3.7	68	wsw.	8.5	2903	514.4	−15.3	......	sw.	....
11:13 a. m....	700.6	− 3.6	68	wsw.	8.9	2956	510.7	−15.7	......	sw.	....
11:20 a. m....	700.6	− 3.5	67	wsw.	8.0	2858	517.3	−14.9	......	sw.	....
11:23 a. m....	700.6	− 3.5	67	wsw.	9.4	2587	536.0	−15.9	......	sw.	....
11:38 a. m....	700.6	− 3.8	72	wsw.	12.1	2091	572.2	−12.9	......	sw.	....
11:50 a. m....	700.6	− 3.8	72	wsw.	11.2	1214	641.4	− 9.5	......	wsw.	....
11:59 a. m....	700.6	− 3.9	72	wsw.	10.7	1171	645.1	− 8.6	......	wsw.	....
12:07 p. m....	700.6	− 4.0	72	w.	12.1	887	669.0	− 8.0	......	w.	....
12:11 p. m....	700.6	− 4.0	72	w.	12.5	526	700.6	− 4.0	72	w.	12.5

January 20.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 6000 m.; at maximum altitude, 5000 m.

The sky was covered with Ci.-St. from the west. A solar halo was observed until 11:20 a. m.

High pressure was central over North Carolina and low pressure over Wisconsin.

January 21.—Two kites were used; lifting surface, 10.8 sq. m. Wire out, 1400 m.; at maximum altitude, 500 m.

The sky was covered with St. from the west-southwest. Light rain fell until 3:40 p. m. and from 5:15 p. m. until after the close of the flight.

At 8 a. m. a trough of low pressure, with primary depression over Virginia, extended from Georgia northward into Canada. Pressure was high off Nova Scotia and in the Southwest.

January 22.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 5000 m.; at maximum altitude, 4500 m.

There were 5/10 to 8/10 St.-Cu. from the southwest at an altitude of about 2300 m. The head kite was in the clouds at intervals from 10:55 to 11:28 a. m.

A low was central over western New York. Pressure was high over Nova Scotia.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Jan. 23.	*mm.*	°*C.*	%		*m. p. s.*	*m.*	*mm.*	°*C.*	%		*m. p. s.*
1:52 p. m...	713.6	− 0.4	66	se.	6.7	526	713.6	− 0.4	66	se.	6.7
1:57 p. m...	713.6	− 0.4	66	se.	6.7	749	693.9	− 1.6	......	sse.	....
2:02 p. m...	713.6	− 0.2	66	se.	6.7	898	681.1	0.6	......	ssw.	....
2:20 p. m...	713.5	0.2	71	se.	5.4	1274	649.7	− 2.8	......	sw.	....
2:24 p. m...	713.4	0.2	71	se.	5.4	1480	633.0	− 2.3	......	sw.	....
2:32 p. m....	713.4	− 0.1	66	se.	5.4	1738	612.7	− 3.8	......	sw.	....
3:06 p. m...	713.2	− 0.1	58	se.	6.3	2369	564.7	− 7.8	......	sw.	....
3:39 p. m...	713.2	0.1	64	se.	5.4	1730	612.7	− 3.8	......	sw.	....
3:47 p. m...	713.2	0.2	64	se.	5.4	1472	633.0	− 4.4	......	sw.	....
3:53 p. m...	713.2	0.3	62	se.	5.8	1199	655.2	− 3.2	......	ssw.	....
4:00 p. m....	713.2	0.3	62	se.	5.8	828	686.7	− 2.5	......	s.	....
4:06 p. m...	713.2	0.3	62	se.	5.8	526	713.2	0.3	62	se.	5.8
Jan. 24.											
8:45 p. m...	715.0	− 2.3	100	nnw.	4.5	526	715.0	− 2.3	100	nnw.	4.5
8:55 p. m....	715.0	− 2.3	100	nnw.	4.0	859	685.8	− 1.6	......	nnw.	....
9:24 p. m....	715.0	− 2.2	100	nnw.	3.1	1521	630.5	− 6.8	......	nnw.	....
9:44 p. m...	715.1	− 2.2	100	nnw.	3.1	1778	610.1	− 8.3	......	nnw.	....
9:59 p. m....	715.1	− 2.2	100	nnw.	4.0	1402	640.1	− 6.6	......	nnw.	....
10:15 p. m....	715.1	− 2.3	100	nnw.	4.9	878	684.1	− 2.7	......	nnw.	....
10:24 p. m...	715.1	− 2.4	100	nnw.	4.9	526	715.1	− 2.4	100	nnw.	4.9
Jan. 25.											
10:29 a. m....	716.2	− 3.8	70	nw.	12.5	526	716.2	− 3.8	70	nw.	12.5
10:36 a. m....	716.3	− 3.8	72	nw.	10.7	865	686.0	− 7.9	......	nw.	....
11:00 a. m....	716.3	− 3.2	69	nw.	10.7	1360	643.6	−10.0	......	nnw.	....
11:19 a. m....	716.3	− 2.9	68	nw.	10.7	1633	621.4	− 5.3	......	nw.	....
11:27 a. m....	716.3	− 3.0	68	nw.	9.8	2198	578.2	− 7.0	......	nw.	....
11:54 a. m....	716.3	− 2.6	67	nw.	10.7	3239	505.2	−13.7	......	nw.	....
12:43 p. m....	715.9	− 2.2	67	wnw.	13.4	4029	455.0	−14.7	......	nw.	....
2:08 p. m....	715.3	− 1.8	59	nw.	13.4	3184	509.0	−11.1	......	nw.	....
2:30 p. m....	715.3	− 1.6	60	nw.	13.4	2200	578.2	− 7.9	......	nnw.	....
2:46 p. m....	715.3	− 1.5	62	nw.	11.6	1585	625.2	− 2.0	......	nnw.	....
2:57 p. m....	715.3	− 1.4	64	nw.	11.6	1309	647.4	− 7.7	......	nw.	....
3:02 p. m....	715.3	− 1.4	65	nw.	11.6	901	682.3	− 5.9	......	nw.	....
3:11 p. m....	715.3	− 1.5	66	nw.	10.7	526	715.3	− 1.5	66	nw.	10.7

January 23.—Three kites were used; lifting surface, 19.4 sq. m. Wire out, 4500 m.; at maximum altitude, 4450 m.

About 9/10 A.-St. from the southwest at an altitude of 2000 m. were present during the flight.

At 8 a. m. pressure was low north of the upper Lakes and high off the southern coast of Florida.

January 24.—Three kites were used; lifting surface, 19.4 sq. m. Wire out, 2200 m., at maximum altitude.

Dense fog prevailed. Light snow fell from 9:05 to 10 p. m.

Pressure was low north of Lake Ontario. High pressure was central over the upper Mississippi Valley and over Nova Scotia.

January 25.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 7000 m.; at maximum altitude, 6600 m.

A few to 3/10 St.-Cu. from the northwest were present during the flight.

Moderately high pressure, central over Ohio, covered the eastern half of the United States.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Jan. 26.	*mm.*	*°C.*	*%*		*m. p. s.*	*m.*	*mm.*	*°C.*	*%*		*m. p. s.*
8:58 a. m....	713.9	− 4.4	77	sse.	7.2	526	713.9	− 4.4	77	sse.	7.2
9:16 a. m....	713.7	− 4.2	81	se.	6.7	1118	663.0	5.3	......	sw.	....
9:44 a. m....	713.4	− 4.5	84	se.	6.7	1557	627.9	2.7	......	sw.	....
10:20 a. m....	713.0	− 4.3	86	se.	6.7	2126	584.6	− 2.1	......	sw.	....
10:37 a. m....	712.9	− 4.0	86	se.	6.7	2688	544.6	− 4.7	......	sw.	....
11:12 a. m....	712.5	− 3.6	84	se.	7.2	3443	494.8	− 4.7	......	wsw.	....
11:36 a. m....	712.2	− 3.8	91	se.	7.6	4062	457.7	− 8.8	......	w.	....
12:19 p. m....	711.4	− 3.5	96	se.	7.6	3512	491.0	− 5.7	......	w.	....
12:26 p. m....	711.3	− 3.4	96	se.	7.6	3422	496.7	− 6.3	......	wsw.	....
12:52 p. m....	710.6	− 3.1	91	sse.	7.6	2710	542.8	− 2.6	......	wsw.	....
1:33 p. m....	709.7	− 3.1	94	se.	8.9	2158	580.9	1.3	......	sw.	....
2:15 p. m....	708.8	− 2.8	94	sse.	8.5	1516	627.9	4.3	......	sw.	....
2:38 p. m....	708.5	− 3.1	96	se.	8.9	928	674.2	8.6	......	ssw.	....
2:47 p. m....	708.4	− 2.9	96	se.	11.2	526	708.4	− 2.9	96	se.	11.2
Jan. 27.											
9:05 a. m....	702.4	3.8	68	wnw.	16.1	526	702.4	3.8	68	wnw.	16.1
9:12 a. m....	702.4	3.7	69	wnw.	14.3	865	673.5	1.0	......	wnw.	....
9:22 a. m....	702.4	3.8	69	wnw.	13.9	1200	645.9	− 1.5	......	wnw.	....
9:35 a. m....	702.5	3.9	69	wnw.	14.8	1649	610.8	− 3.1	......	w.	....
9:46 a. m....	702.5	3.8	68	wnw.	14.3	2079	578.7	− 4.0	......	w.	....
10:05 a. m....	702.6	3.8	68	wnw.	12.5	2128	575.0	− 5.0	......	w.	....
10:30 a. m....	702.9	3.8	69	wnw.	8.0	1603	614.5	− 4.1	......	w.	....
10:50 a. m....	703.2	4.1	69	wnw.	8.0	1211	645.9	− 1.2	......	w.	....
11:00 a. m....	703.3	4.0	68	wnw.	7.6	898	671.7	1.8	......	wnw.	....
11:08 a. m....	703.3	4.0	68	wnw.	7.6	526	703.3	4.0	68	wnw.	7.6
Jan. 28.											
2:23 p. m....	706.5	− 2.0	100	se.	6.3	526	706.5	− 2.0	100	se.	6.3
2:29 p. m....	706.3	− 2.0	100	se.	6.3	863	676.9	− 3.9	......	se.	....
2:42 p. m....	706.1	− 2.1	100	se.	7.6	989	666.0	− 1.6	......	sse.	....
2:46 p. m....	706.0	− 2.1	100	se.	8.0	1166	651.2	− 2.0	......	sse.	....
3:23 p. m....	705.6	− 2.0	100	ese.	7.6	898	673.2	− 1.2	......	sse.	....
3:53 p. m....	705.4	− 2.0	100	ese.	6.7	745	686.2	− 3.6	......	se.	....
4:00 p. m....	705.4	− 2.0	100	ese.	7.2	526	705.4	− 2.0	100	se.	7.2

January 26.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 7500 m.; at maximum altitude, 7300 m.

A.-St. from the west-southwest covered the sky. Their altitude was about 2700 m. at 10:30 a. m. and about 3400 m. at 12:30 p. m. Rain and sleet fell from 10:33 a. m. to 12:10 p. m. At frequent intervals from 12:50 p. m. until the close of the flight St. from the south passed over the station at a gradually diminishing altitude.

At 8 a. m. pressure was low over Iowa and comparatively high over the Atlantic coast States.

January 27.—Two kites were used; lifting surface, 10.8 sq. m. Wire out, 3000 m.; at maximum altitude, 2600 m.

There were 6/10 to 9/10 St.-Cu. from the west. The head kite was in the clouds at intervals from 9:37 to 10:25 a. m.

Pressure was low over Ontario and high over southern Florida.

January 28.—Three kites were used; lifting surface, 19.4 sq. m. Wire out, 2400 m.; at maximum altitude, 1500 m.

Dense fog and snow prevailed during the flight.

Centers of low pressure lay over the lower St. Lawrence and over Georgia.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Jan. 29.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
5:12 p. m....	706.5	− 3.7	66	wnw.	22.4	526	706.5	− 3.7	66	wnw.	22.4
5:23 p. m....	706.7	− 3.7	66	wnw.	20.6	982	666.5	− 7.3	......	wnw.	....
5:33 p. m....	707.0	− 3.8	66	wnw.	20.6	1251	644.3	− 9.2	......	wnw.	....
5:57 p. m....	707.5	− 3.8	67	wnw.	17.9	950	670.2	− 7.2	......	wnw.	....
6:11 p. m....	707.9	− 4.0	68	wnw.	17.9	526	707.9	− 4.0	68	wnw.	17.9
Jan. 30.											
9:04 a. m....	713.9	− 1.3	54	s.	7.2	526	713.9	− 1.3	54	s.	7.2
9:11 a. m....	713.9	− 1.4	56	sse.	7.2	784	691.0	− 3.4	......	s.	....
9:22 a. m....	713.9	− 1.5	59	s.	7.6	892	681.7	− 2.3	......	ssw.	....
9:42 a. m....	714.0	− 1.2	59	s.	8.0	1241	652.3	− 4.3	......	sw.	....
9:53 a. m....	714.0	− 1.0	57	s.	7.6	2122	583.1	− 7.8	......	wsw.	....
9:56 a. m....	714.0	− 0.9	57	s.	7.6	2334	567.4	− 6.4	......	wsw.	....
10:40 a. m....	713.9	− 0.9	62	s.	6.3	2989	521.5	−10.2	......	wsw.	....
11:11 a. m....	713.7	− 1.9	67	s.	5.8	2341	567.4	− 6.6	......	wsw.	....
11:33 a. m....	713.4	− 1.5	64	s.	6.3	2125	583.1	− 8.0	......	sw.	....
11:55 a. m....	713.2	− 1.0	61	s.	8.9	1704	615.3	− 5.9	......	sw.	....
12:06 p. m....	713.0	− 1.2	61	s.	6.3	1285	648.5	− 2.3	......	sw.	....
12:21 p. m....	712.9	− 1.3	65	s.	5.4	885	681.7	1.5	......	ssw.	....
12:31 p. m....	712.8	− 1.9	69	s.	5.8	526	712.8	− 1.9	69	s.	5.8
Jan. 31.											
9:07 a. m....	713.2	− 2.6	87	nnw.	7.6	526	713.2	− 2.6	87	nnw.	7.6
9:19 a. m....	713.2	− 2.6	87	nw.	7.6	783	....	− 4.7	......	nnw.	....
11:18 a. m....	713.2	− 3.0	82	nw.	7.6	989	672.5	− 6.4	......	nw.	....
11:30 a. m....	713.2	− 3.0	82	nw.	7.6	798	689.0	− 5.7	......	nnw.	....
11:35 a. m....	713.2	− 3.0	82	nw.	7.6	526	713.2	− 3.0	82	nw.	7.6

January 29.—One kite was used; lifting surface, 5.4 sq. m. Wire out, 1500 m., at maximum altitude.

About 2/10 A.-St. from the west, and 6/10 St.-Cu. from the west-northwest, were present during the flight.

At 8 a. m. very low pressure was central off the New Jersey coast.

January 30.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 4400 m.; at maximum altitude, 3900 m.

There were 8/10 to 10/10 A.-St. from the west. A solar halo was observed from 9:33 to 9:38 a. m. A driving snow was observed between the surface and the head kite from 11:50 a. m. to 12:20 p. m., but no snow fell to the ground.

Low pressure was central over New Brunswick and pressure was relatively low over Michigan. Pressure was high off the south Atlantic coast.

January 31.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 3000 m.; at maximum altitude, 1000 m.

The sky was covered with St. from the west-southwest. Light snow fell after 9:30 a. m.

Pressure was high over the Mississippi Valley and relatively low along the Atlantic coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Feb. 1.	mm.	° C.	%		m. p. s.	m.	mm.	° C.	%		m. p. s.
2:05 p. m....	716.9	− 2.1	59	nw.	13.4	526	716.9	− 2.1	59	nw.	13.4
2:11 p. m....	716.9	− 2.0	59	nw.	13.9	874	686.0	− 6.0	......	nw.	....
2:17 p. m....	716.9	− 2.0	57	nw.	13.4	1197	658.2	− 7.8	......	nw.	....
2:21 p. m...	716.9	− 2.0	57	nw.	13.4	1306	649.0	− 5.3	......	nw.	....
2:36 p. m...	716.9	− 1.8	53	wnw.	13.9	1629	623.1	− 2.3	......	nnw.	....
2:50 p. m...	716.9	− 2.0	57	nw.	14.3	2264	575.3	− 2.6	......	nnw.	....
3:03 p. m...	716.9	− 1.8	56	wnw.	13.4	3001	523.7	− 8.1	......	nnw.	....
3:27 p. m...	717.0	− 1.8	52	wnw.	11.2	3909	466.0	−12.1	......	nnw.	....
3:42 p. m...	717.0	− 1.7	52	nw.	13.4	3469	493.6	− 9.5	......	nnw.	....
3:59 p. m...	717.1	− 2.0	51	wnw.	11.6	2162	583.5	− 2.9	......	nnw.	....
4:19 p. m...	717.1	− 2.2	49	wnw.	13.4	1314	649.0	− 0.5	......	nnw.	....
4:26 p. m....	717.1	− 2.4	46	wnw.	13.4	962	678.6	− 6.2	......	nw.	....
4:34 p. m...	717.1	− 2.6	49	wnw.	14.3	836	689.5	− 5.5	......	nw.	....
4:37 p. m....	717.1	− 2.6	49	wnw.	13.4	526	717.1	− 2.6	49	wnw.	13.4
Feb. 2.											
4:31 p. m....	716.3	7.6	40	ssw.	5.4	526	716.3	7.6	40	ssw.	5.4
5:02 p. m...	716.3	7.4	38	ssw.	5.8	901	684.4	6.0	......	sw.	....
5:50 p. m...	716.3	6.2	37	ssw.	6.3	1461	638.7	2.4	......	w.	....
6:00 p. m...	716.3	5.2	38	ssw.	5.8	1724	618.0	1.1	......	w.	....
6:25 p. m...	716.3	4.8	42	ssw.	6.7	2250	578.4	− 2.9	......	w.	....
7:10 p. m...	716.3	5.1	37	ssw.	7.6	2628	551.4	− 4.1	......	w.	....
7:27 p. m....	716.3	5.4	37	ssw.	7.6	3342	503.6	− 7.0	......	w.	....
7:47 p. m....	716.2	5.2	38	ssw.	7.2	2548	557.0	− 3.5	......	w.	....
8:03 p. m....	716.2	5.4	38	ssw.	8.0	1895	605.0	1.0	......	w.	....
8:16 p. m....	716.1	5.6	37	ssw.	7.2	1232	656.8	4.4	......	wsw.	....
8:24 p. m....	716.0	5.6	38	ssw.	7.2	898	684.4	7.0	......	sw.	....
8:29 p. m....	716.0	6.0	35	ssw.	7.6	526	716.0	6.0	35	ssw.	7.6
Feb. 3.											
1:58 p. m....	708.4	3.4	100	wsw.	6.3	526	708.4	3.4	100	wsw.	6.3
2:15 p. m....	708.2	3.4	100	wsw.	5.8	928	673.6	0.0	......	wsw.	....
2:42 p. m....	707.8	3.3	100	wsw.	5.8	1446	631.1	− 0.5	......	w.	....
3:30 p. m....	707.2	4.2	80	w.	5.8	2087	582.2	− 1.0	......	w.	....
4:09 p. m....	706.9	4.1	80	w.	5.4	2379	560.9	− 4.0	......	w.	....
4:32 p. m....	706.9	4.1	79	w.	4.0	2797	531.8	− 4.8	......	w.	....
4:56 p. m....	706.9	3.7	83	w.	4.0	2397	559.0	− 3.0	......	w.	....
5:00 p. m....	706.9	3.5	83	w.	4.0	2052	584.1	− 4.8	......	w.	....
5:10 p. m....	706.9	3.1	88	nw.	3.6	1436	631.1	− 1.9	......	wnw.	....
5:18 p. m....	707.0	2.8	91	nw.	3.1	784	684.7	1.1	......	wnw.	....
5:29 p. m....	707.0	2.8	87	nw.	2.7	526	707.0	2.8	87	nw.	2.7

February 1.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 6000 m.; at maximum altitude, 5600 m.

Ci.-St., from the north-northwest, appeared at 3:45 p. m. and increased to 3/10 by the end of the flight.

At 8 a. m., high pressure, central over Kentucky, covered the eastern part of the United States. Pressure was low off the coast of southern New England.

February 2.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 4500 m.; at maximum altitude, 4200 m.

A.-Cu. from the west diminished from 7/10 at 4:31 to a few at 8:01 p. m.

At 8 a. m. pressure was high over West Virginia and low over Iowa.

February 3.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 5500 m.; at maximum altitude, 4400 m.

The sky was covered with St. and St.-Cu. clouds at an altitude of about 1500 m. They were moving from the west until about 5 p. m. and from the west-northwest thereafter. Light rain fell until 3:10 p. m.

At 8 a. m. pressure was low over the lower Lakes and comparatively high over Florida.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity					Dir.	Velocity.
1910.											
Feb. 4.	*mm.*	*°C.*	%		*m. p. s.*	*m.*	*mm.*	*°C.*	%		*m. p. s.*
2:32 p. m....	711.5	2.8	30	wnw.	15.2	526	711.5	2.8	30	wnw.	15.2
2:40 p. m....	711.3	3.0	28	wnw.	16.1	859	682.5	− 0.9	......	wnw.	....
2:56 p. m....	710.9	2.7	27	wnw.	19.7	1081	663.3	− 2.8	......	wnw.	....
3:05 p. m....	710.9	2.8	33	wnw.	19.7	1427	635.1	− 4.0	......	nw.	....
3:23 p. m....	710.9	2.8	36	w.	17.9	1914	597.2	− 2.4	......	nw.	....
3:55 p. m....	710.9	3.0	27	w.	18.8	2304	568.0	− 7.2	......	nw.	....
4:32 p. m....	711.0	3.1	28	wnw.	11.6	2044	586.9	− 8.2	......	wnw.	....
4:58 p. m....	711.0	2.7	32	wnw.	14.3	1586	....	− 4.6	......	wnw.	....
5:07 p. m....	711.0	2.5	36	wnw.	12.5	1448	633.2	− 5.7	......	wnw.	....
5:30 p. m....	711.0	2.1	30	wnw.	11.6	855	682.5	− 0.5	......	wnw.	....
5:36 p. m....	711.1	2.0	29	wnw.	15.6	526	711.1	2.0	29	wnw.	15.6
Feb. 5.											
8:39 a. m....	710.6	− 3.2	63	nw.	12.5	526	710.6	− 3.2	63	nw.	12.5
8:44 a. m....	710.6	− 3.2	62	nw.	12.5	851	681.8	− 6.8	......	nw.	....
8:57 a. m....	710.8	− 3.1	59	nw.	16.1	1164	655.0	−10.0	......	nw.	....
9:07 a. m....	710.8	− 2.8	57	nw.	16.1	1528	624.9	−12.8	......	wnw.	....
9:20 a. m....	710.9	− 2.8	57	nw.	13.4	2045	584.3	−15.5	......	wnw.	....
9:54 a. m....	711.1	− 3.0	57	nw.	12.5	2447	554.4	− 8.6	......	wnw.	....
10:40 a. m.. .	711.0	− 2.7	54	nw.	15.2	3461	485.4	−17.2	......	wnw.	....
1:40 p. m....	710.3	− 0.6	48	wnw.	11.6	526	710.3	− 0.6	48	wnw.	11.6
Feb. 6.											
9:41 a. m....	713.0	−11.2	63	wnw.	13.9	526	713.0	−11.2	63	wnw.	13.9
9:50 a. m....	713.0	−11.5	63	wnw.	13.4	837	684.4	−15.8	......	nw.	....
10:03 a. m....	713.0	−10.6	59	wnw.	15.2	1115	659.5	−19.9	......	nw.	....
10:14 a. m....	713.0	−11.0	57	wnw.	15.2	1579	619.4	−24.8	......	nw.	....
10:35 a. m....	713.0	−10.8	57	wnw.	16.1	1787	601.6	−28.4	......	nw.	....
11:07 a. m....	713.0	−10.6	59	wnw.	16.1	2037	581.1	−31.4	......	nw.	....
11:26 a. m....	713.0	−10.6	59	wnw.	21.5	1766	603.6	−27.1	......	nw.	....
12:00 m......	713.0	−10.8	50	wnw.	16.1	1599	617.5	−26.4	......	nw.	....
12:20 p. m....	713.0	−10.9	53	wnw.	16.1	1481	627.5	−25.0	......	nw.	....
12:55 p. m....	713.0	−11.1	57	wnw.	16.1	986	671.0	−19.0	......	nw.	....
1:32 p. m....	713.0	−11.2	57	wnw.	23.7	526	713.0	−11.2	57	wnw.	23.7

February 4.—Three kites were used; lifting surface, 14.5 sq. m. Wire out, 5000 m.; at maximum altitude, 4600 m.

A few Ci.-Cu. from the northwest were visible during the flight.

Low pressure was central off the Rhode Island coast, with a secondary depression north of Lake Huron. Pressure was high over the West and the South.

February 5.—Three kites were used; lifting surface, 16.2 sq. m. Wire out, 6500 m.; at maximum altitude, 6200 m.

St.-Cu. clouds from the west-northwest, decreased in amount from 7/10 to 2/10. After 8:44 a. m. from 1/10 to 2/10 A.-St. from the same direction were present.

Low pressure was central over Quebec, with a secondary depression over Missouri.

February 6.—Two kites were used; lifting surface, 10.8 sq. m. Wire out, 4000 m.; at maximum altitude, 3200 m.

There were 3/10 to 8/10 St.-Cu. from the northwest. Light snow fell from 11:16 to 11:28 a. m. and after 1 p. m. The head kite was in the clouds at intervals from 10:13 a. m. to 12:01 p. m.

Pressure was high over Iowa and low over Nova Scotia.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Feb. 7.	*mm.*	*° C.*	%		*m. p. s.*	*m.*	*mm.*	*° C.*	%		*m. p. s.*
8:49 a. m....	722.7	−15.1	58	wnw.	8.9	526	722.7	−15.1	58	wnw.	8.9
8:55 a. m....	722.8	−14.7	53	wnw.	8.9	854	691.8	−18.8	......	wnw.	....
9:04 a. m....	722.8	−14.3	47	wnw.	8.9	1306	651.7	−12.8	......	wnw.	....
9:17 a. m....	722.9	−13.9	40	wnw.	8.5	1629	625.0	−10.1	......	nw.	....
9:26 a. m...	723.0	−13.6	40	nw.	8.0	1758	614.9	−11.0	......	nw.	....
9:39 a. m....	723.2	−13.5	41	nw.	8.0	2396	566.4	− 8.0	......	nw.	....
9:56 a. m....	723.3	−13.0	43	nw.	6.7	2809	537.2	−10.4	......	nnw.	....
10:10 a. m....	723.3	−12.5	38	nw.	7.6	3082	518.7	−10.4	......	nnw.	....
11:11 a. m ...	723.3	−10.2	28	wnw.	8.5	2796	539.1	− 9.4	......	nnw.	....
11:40 a. m....	723.0	− 9.4	24	wnw.	6.3	2388	568.4	− 6.4	......	nnw.	....
11:53 a. m....	722.9	− 9.2	25	wnw.	5.8	1929	602.7	− 7.3	......	nw.	....
12:11 p. m....	722.8	− 8.4	29	wnw.	5.4	1525	635.0	− 7.6	......	nw.	....
12:16 p. m....	722.8	− 8.0	30	wnw.	5.4	779	699.5	−12.0	......	wnw.	....
12:21 p. m...	722.7	− 8.1	33	wnw.	5.4	526	722.7	− 8.1	33	wnw.	5.4
Feb. 8.											
8:38 a. m....	720.7	1.8	45	wsw.	6.3	526	720.7	1.8	45	wsw.	6.3
8:45 a. m....	720.7	1.7	39	wsw.	6.3	722	703.4	3.0	......	wsw.	....
9:20 a. m....	720.7	2.7	39	w.	3.6	1315	653.5	− 0.2	......	w.	....
9:42 a. m....	720.7	2.4	41	w.	4.0	1731	620.3	− 3.5	......	wsw.	....
10:06 a. m....	720.7	2.5	41	w.	5.4	2027	597.4	− 5.5	......	wsw.	....
10:48 a. m....	720.7	4.6	36	w.	3.6	2251	580.7	− 6.8	......	wsw.	....
11:07 a. m....	720.6	4.6	35	w.	4.0	2755	544.4	− 8.9	......	wsw.	....
11:37 a. m....	720.3	5.6	31	wsw.	3.1	3296	507.7	−12.0	......	wsw.	....
12:11 p. m....	719.8	6.8	34	sw.	1.8	3724	480.2	−14.0	......	sw.	....
1:00 p. m....	719.0	4.6	47	se.	2.7	3221	511.5	−11.5	......	sw.	....
2:00 p. m....	718.3	3.4	52	s.	2.7	3037	522.8	−10.0	......	sw.	....
3:10 p. m....	718.3	3.0	52	s.	5.4	2022	595.5	− 5.5	......	wsw.	....
3:25 p. m....	718.3	2.9	52	s.	4.5	1242	657.3	− 1.5	......	wsw.	....
3:33 p. m....	718.3	2.9	52	s.	4.5	804	694.1	3.5	......	sw.	....
3:38 p. m....	718.3	2.6	56	s.	4.5	526	718.3	2.6	56	s.	4.5

February 7.—Two kites were used; lifting surface, 12.6 sq. m. Wire out, 7100 m.; at maximum altitude, 5700 m.

There were no clouds.

At 8 a. m. an extensive high was central over the Virginias. Pressure was relatively low off Nova Scotia.

February 8.—Six kites were used, lifting surface, 38.3 sq. m. Wire out, 7500 m.; at maximum altitude, 6000 m.

There were 5/10 to 10/10 A.-St. from the west-southwest until 12:08 p. m., from the southwest thereafter. 2/10 Ci. from the west-southwest were visible from 9:20 to 9:36 a. m. A halo was observed. The head kite entered the clouds at 12:10 p. m. and emerged at 1:39 p. m.

Pressure was high over the North Carolina coast and low over Lake Superior.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Feb. 9.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
8:28 a. m....	714.6	2.3	76	s.	9.4	526	714.6	2.3	76	s.	9.4
8:49 a. m....	714.4	0.6	82	s.	9.4	1059	668.8	3.3	......	s.	....
9:02 a. m....	714.2	0.6	84	sse.	8.0	1682	618.8	− 0.7	......	ssw.	....
9:18 a. m....	713.9	0.6	84	sse.	7.2	2129	584.8	− 2.3	......	ssw.	....
9:35 a. m....	713.6	0.9	82	s.	6.3	2553	554.1	− 3.6	....	ssw.	....
9:58 a. m....	713.2	− 2.4	100	sse.	6.7	2259	574.7	− 2.5	......	ssw.	....
10:55 a. m....	712.5	− 2.7	100	sse.	7.6	1518	629.9	1.0	......	ssw.	....
11:10 a. m....	712.3	− 2.6	100	se.	5.8	526	712.3	− 2.6	100	se.	5.8
Feb. 10.											
9:19 a. m....	717.8	− 5.0	47	nw.	15.2	526	717.8	− 5.0	47	nw.	15.2
9:26 a. m....	718.0	− 5.2	47	nw.	15.2	777	695.3	− 9.1	......	nw.	....
9:41 a. m....	718.3	− 5.1	47	nw.	15.6	1016	674.3	−12.6	......	nw.	....
9:52 a. m....	718.5	− 5.1	47	nw.	13.0	1350	645.6	−15.2	......	nw.	....
10:06 a. m....	718.6	− 5.0	47	nw.	10.7	1698	617.0	−16.5	......	nw.	....
10:25 a. m....	718.8	− 4.6	49	nw.	10.7	2038	590.2	−10.8	......	wnw.	....
10:45 a. m....	718.9	− 4.6	48	wnw.	13.4	2572	550.5	−14.5	......	wnw.	....
11:16 a. m....	719.0	− 3.9	41	wnw.	9.4	2958	523.2	−17.2	......	wnw.	....
12:30 p. m....	718.9	− 2.9	40	nw.	12.5	2317	569.2	−12.5	......	nw.	....
12:51 p. m....	718.8	− 2.5	41	nw.	12.5	1928	598.5	−19.1	......	nw.	....
1:08 p. m....	718.8	− 2.4	42	nw.	12.5	1467	636.5	−15.6	......	wnw.	....
1:16 p. m....	718.8	− 2.2	44	nw.	12.5	1246	655.2	−12.7	......	nw.	....
1:29 p. m....	718.8	− 2.2	43	nw.	13.4	876	687.6	− 7.3	......	nw.	....
1:34 p. m....	718.8	− 2.2	43	nw.	16.1	526	718.8	− 2.2	43	nw.	16.1
Feb. 11.											
9:02 a. m....	726.1	− 7.0	84	e.	5.8	526	726.1	− 7.0	84	e.	5.8
9:15 a. m....	726.0	− 7.0	84	e.	5.8	756	705.0	− 8.0	......	ese.	....
10:56 a. m....	725.7	− 7.6	94	ese.	7.2	1225	662.9	− 9.5	......	se.	....
11:10 a. m....	725.7	− 7.6	94	ese.	5.4	1028	680.1	−10.6	......	se.	....
11:14 a. m....	725.7	− 7.6	94	ese.	5.8	857	695.4	− 9.4	......	ese.	....
11:26 a. m....	725.7	− 7.6	94	ese.	5.4	526	725.7	− 7.6	94	ese.	5.4

February 9.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 6000 m.; at maximum altitude, 4500 m.

The sky was covered with St.-Cu. from the west. Dense fog set in at 9:55 a. m. Light rain fell from 9:17 to 9:22, and after 10:41 a. m. The head kite was at the base of the St.-Cu at 9:09 a. m.; altitude, 2000 m.

A trough of low pressure extended from the St. Lawrence Valley to Tennessee. Pressure was high off the Atlantic coast.

February 10.—Three kites were used; lifting surface, 16.2 sq. m. Wire out, 7500 m.; at maximum altitude, 6900 m.

From 1/10 to 2/10 St.-Cu. from the northwest were present during the flight.

Low pressure was central over Maine and pressure was high over the upper Mississippi Valley.

February 11.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 3400 m. at maximum altitude, 1200 m.

The sky was covered with St. from the southeast.

Pressure was high over New York and low over southern Alabama.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Feb. 12.	mm.	°C.	%		m. p. s.	m.	mm.	°C.	%		m. p. s.
9:42 a. m....	705.0	− 7.6	98	wnw.	6.7	526	705.0	− 7.6	98	wnw.	6.7
9:46 a. m....	705.0	− 7.4	98	wnw.	7.2	888	672.9	− 6.4	......	w.	....
9:57 a. m....	705.1	− 6.8	99	w.	8.9	1275	640.5	− 7.4	......	wnw.	....
10:18 a. m....	705.1	− 6.1	92	w.	8.9	1897	591.5	− 7.1	......	wnw.	....
10:36 a. m....	705.2	− 4.7	84	w.	14.8	2390	555.2	−10.1	......	w.	....
10:52 a. m....	705.2	− 4.2	77	w.	13.9	2578	541.5	−12.0	......	w.	....
11:23 a. m....	705.3	− 3.6	73	w.	12.5	1919	589.6	− 6.9	......	w.	....
11:46 a. m....	705.4	− 2.8	68	w.	12.5	1581	616.1	−11.5	......	wnw.	....
11:53 a. m....	705.5	− 2.6	66	wnw.	13.0	1260	642.4	− 9.1	......	wnw.	....
12:14 p. m....	705.5	− 2.0	63	wnw.	13.4	526	705.5	− 2.0	63	wnw.	13.4
Feb. 13.											
9:21 a. m....	714.2	− 8.6	63	wnw.	13.4	526	714.2	− 8.6	63	wnw.	13.4
9:25 a. m....	714.2	− 8.6	63	wnw.	13.4	819	687.6	−11.9	......	wnw.	....
9:33 a. m....	714.2	− 8.4	64	wnw.	16.1	1123	660.8	−13.7	......	wnw.	....
9:39 a. m....	714.2	− 8.4	64	wnw.	15.2	1165	657.0	−12.8	......	nw.	....
9:46 a. m....	714.3	− 8.0	65	wnw.	16.5	1388	638.3	−13.8	......	nw.	....
9:53 a. m....	714.3	− 8.0	64	wnw.	14.8	1773	606.8	−14.4	......	nw.	....
10:29 a. m....	714.4	− 7.4	61	wnw.	12.5	2336	563.4	−17.3	......	nw.	....
10:57 a. m....	714.6	− 6.5	58	wnw.	13.4	1861	600.4	−14.7	......	nw.	....
11:23 a. m....	714.6	− 6.8	62	wnw.	14.3	1263	649.4	−12.1	......	nw.	....
11:32 a. m....	714.5	− 6.5	63	wnw.	14.3	1040	668.5	−12.8	......	nw.	....
11:50 a. m....	714.5	− 6.2	64	wnw.	15.2	803	689.5	−10.1	......	wnw.	....
11:58 a. m....	714.5	− 6.1	64	wnw.	15.2	526	714.5	− 6.1	64	wnw.	15.2
Feb. 14.											
8:48 a. m....	719.3	− 3.9	57	w.	11.6	526	719.3	− 3.9	57	w.	11.6
8:55 a. m....	719.3	− 3.8	57	w.	10.7	933	683.0	− 7.4	......	w.	....
9:05 a. m....	719.3	− 3.8	55	w.	9.8	1335	648.4	− 9.8	......	w.	....
9:13 a. m....	719.3	− 3.7	56	w.	11.6	1458	638.3	− 8.6	......	wnw.	....
9:44 a. m....	719.3	− 3.2	55	w.	12.1	2510	556.3	−15.7	......	wnw.	....
10:43 a. m....	719.3	− 1.9	51	wnw.	10.7	3036	519.5	−15.2	......	wnw.	....
10:59 a. m....	719.3	− 1.6	56	wnw.	9.8	3646	479.1	−18.5	......	wnw.	....
12:08 p. m....	718.7	− 0.1	52	wnw.	6.3	3136	512.7	−13.0	......	wnw.	....
1:57 p. m....	718.0	1.8	43	w.	6.7	2495	557.6	−14.8	......	w.	....
2:17 p. m....	718.0	2.0	39	w.	6.7	1980	596.7	−12.4	......	w.	....
2:30 p. m....	718.0	2.2	39	w.	7.2	1303	651.1	− 6.3	......	w.	....
2:45 p. m....	718.1	3.4	48	w.	3.6	526	718.1	3.4	48	w.	3.6

February 12.—Three kites were used; lifting surface, 16.2 sq. m. Wire out, 6000 m.; at maximum altitude.

There was 1/10 St.-Cu. from the southwest.

Low pressure, central off the New Jersey coast, covered the Middle Atlantic States and the Lake region. Pressure was high west of the Mississippi and over the Gulf States.

February 13.—Three kites were used; lifting surface, 16.2 sq. m. Wire out, 6000 m., at maximum altitude.

There were from 5/10 to 8/10 A.-St. from the west.

Low pressure was central over New Brunswick, high pressure over Louisiana.

February 14.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 7500 m., at maximum altitude.

3/10 to 7/10 Ci.-St., from the west-northwest, prevailed during the flight. A parhelion was observed at 9 a. m.

At 8 a. m. an area of high pressure, central over the Gulf of Mexico, covered the eastern States. Pressure was relatively low north of the Lake region.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Feb. 15.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
8:37 a. m....	716.7	5.8	52	sw.	6.3	526	716.7	5.8	52	sw.	6.3
10:47 a. m....	716.5	7.0	48	ssw.	5.4	944	681.0	5.6	......	wsw.	....
11:14 a. m....	716.3	7.1	49	ssw.	5.8	1802	612.2	− 1.6	......	wsw.	....
11:24 a. m....	716.2	7.3	48	ssw.	5.4	2541	557.5	− 8.9	......	w.	....
11:33 a. m....	716.2	7.7	46	sw.	5.8	2655	549.7	2.9	......	w.	....
12:14 p. m....	715.9	7.7	46	sw.	4.9	3407	496.2	− 4.4	......	w.	....
1:32 p. m....	715.2	7.1	49	ssw.	6.3	2647	549.7	2.6	......	wsw.	....
1:34 p. m....	715.2	7.1	49	ssw.	6.3	2560	555.6	− 4.3	......	wsw.	....
2:08 p. m....	715.0	7.0	50	ssw.	8.5	2033	593.8	− 2.5	......	wsw.	....
2:31 p. m....	714.8	7.6	49	ssw.	8.5	1658	622.2	0.0	......	wsw.	....
2:53 p. m....	714.7	7.4	48	ssw.	7.6	1250	654.2	3.1	......	sw.	....
3:03 p. m....	714.7	6.7	48	s.	7.6	833	688.6	6.7	......	s.	....
3:11 p. m....	714.6	6.4	51	s.	7.2	526	714.6	6.4	51	s.	7.2
Feb. 16.											
8:49 a. m....	715.4	9.8	66	sw.	7.2	526	715.4	9. 8	66	sw.	7.2
8:58 a. m....	715.4	10.0	66	sw.	7.6	914	683.0	11.1	......	sw.	....
9:13 a. m....	715.4	10.6	65	sw.	5.4	1468	639.0	8.0	......	wsw.	....
9:22 a. m....	715.4	10.4	65	sw.	5.8	1794	614.2	5.5	......	wsw.	....
9:28 a. m....	715.4	10.4	65	sw.	6.3	1894	606.6	6.2	......	wsw.	....
9:42 a. m....	715.4	10.6	65	sw.	6.3	2387	571.3	3.7	......	wsw.	....
10:17 a. m....	715.4	11.0	65	sw.	6.3	3191	516.7	− 2.5	......	wsw.	....
10:42 a. m....	715.4	11.4	63	wsw.	2.7	4271	449.8	−12.1	......	wsw.	....
11:35 a. m....	715.3	11.5	65	sw.	3.6	4010	465.3	−10.3	......	sw.	....
12:15 p. m....	715.1	12.1	62	sw.	5.8	3695	484.7	− 6.6	......	sw.	....
12:54 p. m....	714.8	11.8	64	sw.	6.7	2980	530.4	− 1.3	......	sw.	....
1:47 p. m....	714.6	14.0	58	sw.	5.4	2530	560.8	1.9	......	sw.	....
2:22 p. m....	714.5	15.1	61	sw.	4.5	1864	608.5	6.8	......	sw.	....
2:31 p. m....	714.5	15.1	58	sw.	2.7	1755	616.6	5.5	......	sw.	....
2:48 p. m....	714.4	15.0	58	ssw.	3.1	1385	644.8	7.6	......	sw.	....
3:03 p. m....	714.4	14.7	57	ssw.	4.0	905	683.0	11.6	......	sw.	....
3:09 p. m....	714.4	14.0	58	ssw.	4.0	526	714.4	14.0	58	ssw.	4.0
Feb. 17.											
4:37 p. m....	708.3	0.0	100	se.	6.3	526	708.3	0.0	100	se.	6.3
4:49 p. m....	708.0	− 0.2	100	se.	7.2	949	672.1	9.1	......	s.	....
5:05 p. m....	707.8	− 0.2	100	se.	8.0	1308	643.5	8.6	......	s.	....
5:10 p. m....	707.7	− 0.2	100	ese.	8.0	526	707.7	− 0.2	100	ese.	8.0

February 15.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 7500 m.; at maximum altitude, 7400 m.

There were 8/10 to 10/10 St.-Cu. from the west until 2:08 p. m., from the west-southwest thereafter. The altitude of the clouds was about 2000 m.

Low pressure was central over Iowa, and pressure was high off the south Atlantic coast.

February 16.—Six kites were used, lifting surface, 37.8 sq. m. Wire out, 7500 m., at maximum altitude.

There were 6/10 to 9/10 A.-Cu. from the west-southwest until noon. These diminished to 1/10 at the close of the flight. From 1/10 to 6/10 Ci.-Cu. from the west-southwest were visible during the afternoon.

Pressure was low over Vermont and high off the coast of the Carolinas.

February 17.—One kite was used; lifting surface, 6.3 sq. m. Wire out, 1150 m., at maximum altitude.

There were dense fog and light rain.

A trough of low pressure extended from the Gulf to Virginia. Pressure was high west of the Mississippi and off the south Atlantic coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.						
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Feb. 18.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
1:20 p. m....	716.7	− 6.8	72	nw.	17.4	526	716.7	− 6.8	72	nw.	17.4
1:35 p. m....	716.8	− 6.9	72	nw.	15.6	1047	670.2	−13.0	......	nw.	....
1:47 p. m....	717.0	− 6.9	73	nw.	14.3	1376	642.0	−11.3	......	nw.	....
1:55 p. m....	717.1	− 7.1	75	nw.	15.6	1376	....	−13.7	......	nw.	....
2:08 p. m....	717.1	− 6.7	74	nw.	14.8	1788	608.6	−10.9	......	nw.	....
2:58 p. m....	717.3	− 6.5	69	nw.	15.2	2580	548.4	−14.1	......	wnw.	....
3:08 p. m....	717.4	− 6.7	70	nw.	14.3	2914	525.0	−10.9	......	w.	....
3:24 p. m....	717.5	− 6.5	68	nw.	13.9	3425	491.0	−14.6	......	w.	....
3:48 p. m....	717.9	− 6.3	68	nw.	14.3	2835	530.8	−11.1	......	w.	....
4:15 p. m....	718.0	− 6.4	73	nw.	14.8	2639	544.4	−14.1	......	wnw.	....
4:30 p. m....	718.1	− 6.6	58	nw.	16.1	1792	608.6	−13.4	......	nw.	....
4:36 p. m....	718.1	− 6.7	56	nw.	17.0	1477	634.4	−15.7	......	nw.	....
4:48 p. m....	718.2	− 6.7	57	nw.	15.2	951	679.8	−12.3	......	nw.	....
5:02 p. m....	718.2	− 6.7	66	nw.	15.6	526	718.2	− 6.7	66	nw.	15.6
Feb. 19.											
4:16 p. m....	725.0	− 3.8	55	se.	6.0	526	725.0	− 3.8	55	se.	6.0
5:28 p. m....	725.0	− 4.7	54	se.	6.7	1025	680.2	− 7.9	......	s.	....
5:40 p. m....	725.0	− 4.7	54	se.	8.0	1136	670.6	− 5.1	......	s.	....
5:46 p. m....	725.0	− 4.8	54	se.	8.0	1519	638.6	− 6.8	......	s.	....
6:20 p. m....	725.0	− 5.2	52	se.	8.5	1713	622.9	− 7.0	......	ssw.	....
6:35 p. m....	725.1	− 5.3	60	se.	8.9	2218	583.8	− 9.9	......	ssw.	....
6:42 p. m....	725.1	− 5.3	59	se.	8.0	1497	640.5	− 6.2	......	ssw.	....
6:58 p. m....	725.1	− 5.2	57	sse.	6.7	1225	663.0	− 6.3	......	sse.	....
7:00 p. m....	725.1	− 5.2	57	sse.	6.7	1025	680.2	− 7.7	......	sse.	....
7:05 p. m....	725.1	− 5.2	57	sse.	6.7	852	695.5	− 7.3	......	sse.	....
7:09 p. m....	725.2	− 5.2	57	se.	7.2	526	725.2	− 5.2	57	se.	7.2
Feb. 20.											
9:06 a. m....	725.6	− 6.6	84	se.	8.9	526	725.6	− 6.6	84	se.	8.9
9:11 a. m....	725.6	− 6.6	84	se.	8.5	909	691.2	− 1.4	......	s.	....
9:33 a. m....	725.5	− 6.1	85	se.	8.9	1452	645.8	2.4	......	s.	....
9:43 a. m....	725.5	− 6.1	85	se.	8.0	1962	606.0	− 1.6	......	ssw.	....
9:49 a. m....	725.5	− 5.8	85	se.	7.6	2214	587.2	− 2.8	......	ssw.	....
9:53 a. m....	725.5	− 5.6	80	se.	7.6	2481	567.8	− 1.4	......	ssw.	....
10:10 a. m....	725.5	− 5.6	80	se.	8.0	2816	544.4	− 3.8	......	sw.	....
10:28 a. m....	725.5	− 5.4	81	se.	12.5	3352	508.4	− 7.9	......	sw.	....
11:41 a. m....	725.4	− 4.8	86	se.	9.8	526	725.4	− 4.8	86	se.	9.8

February 18.—Four kites were used; lifting surface, 21.6 sq. m. Wire out, 7000 m.; at maximum altitude 6000 m.

1/10 to 5/10 St.-Cu., from the northwest, prevailed. The head kite entered the clouds at 1:55 p. m. and was above them at intervals until about 3:30 p. m.

At 8 a. m. high pressure was central over Arkansas and low pressure off New England.

February 19.—Four kites were used; lifting surface, 26.2 sq. m.; Wire out, 3300 m.; at maximum altitude, 2000 m.

From a few to 3/10 A.-St. from the southwest.

Pressure was high over Virginia and low over Utah.

February 20.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 6000 m., at maximum altitude.

From 1/10 to 2/10 St. from the south were visible until 9:30, from 2/10 to 7/10 until 9:41, and from 7/10 to 8/10 thereafter. The head kite was above the cloud level after 9:21 a. m.

Pressure was high over New Jersey and low over Oklahoma.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. Feb. 21.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
11:40 a. m....	712.7	10.4	72	sw.	3.6	526	712.7	10.4	72	sw.	3.6
11:55 a. m....	712.7	9.8	74	ssw.	4.5	864	684.3	8.4	......	wsw.	....
12:10 p. m....	712.7	8.4	77	s.	4.9	1298	649.2	7.5	......	w.	....
12:31 p. m....	712.7	6.9	86	s.	7.6	1934	600.6	3.7	......	w.	....
12:43 p. m....	712.7	8.0	77	s.	7.6	2280	575.5	0.7	......	w.	....
1:09 p. m....	712.7	8.1	80	s.	7.2	3299	506.0	− 3.9	......	wsw.	....
1:52 p. m....	712.5	7.6	87	ssw.	4.5	2893	531.3	− 1.8	......	wsw.	....
2:35 p. m....	712.6	7.4	92	wsw.	3.6	1963	597.0	− 0.8	......	w.	....
2:58 p. m....	712.6	8.0	92	wsw.	2.7	1364	643.2	2.2	......	w.	....
3:37 p. m....	712.2	7.8	91	s.	4.0	794	689.4	6.2	......	wsw.	....
3:44 p. m....	712.1	8.0	91	sw.	4.0	526	712.1	8.0	91	sw.	4.0
Feb. 22.											
9:27 a. m....	711.6	5.8	100	w.	8.0	526	711.6	5.8	100	w..	8.0
9:40 a. m....	711.6	6.0	100	w.	8.0	881	681.4	4.6	......	w.	....
9·54 a. m....	711.7	6.2	98	w.	8.0	1273	649.2	1.6	......	wnw.	....
10:08 a. m....	711.7	6.4	96	w.	8.9	1745	612.2	− 1.4	......	wnw.	....
11:14 a. m....	711.9	7.3	67	wnw.	11.2	1304	647.0	0.8	......	wnw.	....
11:21 a. m....	711.9	7.3	64	wnw.	12.5	969	674.4	3.5	......	wnw.	....
11:39 a. m....	712.0	7.3	62	wnw.	16.1	526	712.0	7.3	62	wnw.	16.1
Feb. 23.											
8:45 a. m....	718.0	− 0.8	58	nw.	12.5	526	718.0	− 0.8	58	nw.	12.5
8:48 a. m....	718.0	− 0.6	55	nw.	12.5	834	690.7	− 4.2	......	nw.	....
9:05 a. m....	718.1	− 0.5	50	nw.	13.4	1236	656.3	− 7.6	......	nw.	....
9:13 a. m....	718.2	− 0.6	51	wnw.	13.4	1640	623.4	− 9.1	......	wnw.	....
10:00 a. m....	718.7	− 1.4	57	nw.	11.6	1915	602.1	− 4.6	......	wnw.	....
10:51 a. m....	719.0	− 2.2	55	nw.	17.0	2290	574.2	− 6.2	......	w.	....
11:53 a. m....	719.6	− 1.7	45	nw.	14.8	1870	605.8	− 4.6	......	w.	....
12:00 m......	719.7	− 1.9	44	nw.	15.2	1672	621.5	− 8.0	......	w.	....
1:21 p. m....	719.1	− 1.8	49	nw.	10.7	1152	664.0	− 8.7	......	nw.	....
1:34 p. m....	719.2	− 1.8	41	nw.	13.4	807	694.1	− 6.2	......	nw.	....
1:49 p. m....	719.2	− 2.2	43	nw.	15.2	526	719.2	− 2.2	43	nw.	15.2

February 21.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 5000 m.; at maximum altitude, 4800 m.

At the beginning the sky was covered with St.-Cu., from the southwest. Light rain fell after 12:32 p. m. The head kite entered the cloud base at 12:31 p. m., and dropped below it at 2 p. m.

A trough of low pressure extended from the Gulf of St. Lawrence to the Gulf of Mexico. Pressure was high along the south Atlantic coast and over the upper Mississippi Valley.

February 22.—Two kites were used; lifting surface, 12.6 sq. m. Wire out, 4000 m.; at maximum altitude, 3000 m.

Dense fog prevailed until 9:20 a. m.; 2/10 to 7/10 St. from the west thereafter, at an altitude of about 1500 or 1600 m.

At 8 a. m. pressure was relatively low over the Eastern States.

February 23.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 6000 m.; at maximum altitude, 5500 m.

At the beginning 2/10 Ci.-St. from the west, and 2/10 St.-Cu. from the northwest, were present. The lower clouds disappeared by 10:24 a. m., and the higher clouds increased to 4/10 during the flight.

High pressure was central over Iowa and low pressure over New Brunswick.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Feb. 25.	*mm.*	*° C.*	*%*		*m. p. s.*	*m.*	*mm.*	*° C.*	*%*		*m. p. s.*
8:45 a. m....	725.3	−10.2	60	nnw.	7.6	526	725.3	−10.2	60	nnw.	7.6
8:53 a. m...	725.3	−10.2	60	nnw.	8.5	804	699.6	−11.1	......	nnw.	....
10:22 a. m....	725.3	− 8.6	53	nnw.	7.2	995	682.5	−12.2	......	nnw.	....
10:35 a. m....	725.4	− 8.4	53	nnw.	6.7	1205	664.1	−12.2	......	nnw.	....
10:48 a. m....	725.4	− 7.8	53	nnw.	7.6	526	725.4	− 7.8	53	nnw.	7.6
Feb. 26.											
7:39 a. m....	728.3	− 9.0	96	se.	11.2	526	728.3	− 9.0	96	se.	11.2
7:48 a. m....	728.3	− 8.6	94	se.	11.6	850	698.6	− 6.8	......	sse.	....
7:58 a. m....	728.3	− 8.1	91	se.	10.7	1238	665.2	0.6	......	s.	....
8:15 a. m....	728.3	− 7.9	88	se.	13.9	1521	642.1	− 1.6	......	ssw.	....
8:22 a. m....	728.4	− 7.7	88	se.	13.4	1722	626.3	1.4	......	ssw.	....
8:50 a. m....	728.5	− 6.2	82	se,	14.8	2628	559.4	− 1.7	......	ssw.	....
9:16 a, m....	728.5	− 5.6	74	se.	16.1	3093	527.6	− 4.8	......	ssw.	....
9:48 a. m....	728.5	− 4.9	71	se.	15.6	4050	466.8	− 9.8	......	ssw.	....
11:22 a. m....	728.0	− 2.7	64	se.	15.6	3046	531.4	− 5.6	......	ssw.	....
11:33 a. m....	727.9	− 2.6	65	se.	17.9	2060	601.4	1.9	......	ssw.	....
11:46 a. m....	727.8	− 2.4	67	se.	16.1	1557	639.9	2.5	......	ssw.	....
12:31 p. m....	727.4	− 1.4	53	se.	16.1	526	727.4	− 1.4	53	se.	16.1
Feb. 27.											
6:59 a. m....	721.9	6.2	92	s.	6.7	526	721.9	6.2	92	s.	6.7
7:02 a. m....	721.9	6.2	92	s.	7.6	895	690.2	7.1	......	sw.	....
7:32 a. m....	721.9	7.0	92	s.	13.9	1357	652.4	4.2	......	ssw.	....
7:40 a. m....	721.9	7.3	91	s.	13.4	1654	629.1	5.1	......	ssw.	....
7:47 a. m....	721.9	7.3	90	s.	15.6	1503	641.0	6.5	......	ssw.	....
8:07 a. m....	721.9	7.2	91	s.	15.2	1267	659.6	5.1	......	ssw.	....
9:20 a. m....	721.6	6.8	92	s.	12.1	778	699.8	7.4	......	ssw.	....
9:37 a. m....	721.5	6.6	92	ssw.	13.4	526	721.5	6.6	92	ssw.	13.4
Feb. 28.											
8:33 a. m....	716.4	12.0	93	ssw.	4.9	526	716.4	12.0	93	ssw.	4.9
8:40 a. m....	716.4	12.0	93	ssw.	3.6	785	....	11.4	......	ssw.	....
8:46 a. m....	716.4	12.0	93	ssw.	3.1	526	716.4	12.0	93	ssw.	3.1

February 25.—Five kites were used; lifting surface, 33.0 sq. m Wire out, 3750 m.; at maximum altitude, 3300 m.

The sky was cloudless.

Pressure was high over Ohio and low over Montana.

February 26.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 7800 m., at maximum altitude.

From 7/10 to 9/10 Ci.-St., from the west, were replaced by A.-St. during the latter part of the flight.

High pressure, central over the north Atlantic coast, covered the eastern part of the United States. Pressure was low over the upper Mississippi Valley.

February 27.—Two kites were used; lifting surface, 10.8 sq. m. Wire out, 4000 m.; at maximum altitude, 3000 m.

The sky was covered with Ci.-St. from the west, A.-St. from the west-southwest, St.-Cu. from the south and southwest, and St. from the south. The head kite entered St.-Cu. at 7:18 a. m., altitude about 1300 m.; it emerged from St. near the end of flight at about 700 m. altitude.

Pressure was low over the lower Mississippi Valley and the Lake region. High pressure was central east of the United States.

February 28.—One kite was used; lifting surface, 6.3 sq. m. Wire out, 500 m., at maximum altitude.

The sky was overcast with St. moving rapidly from the southwest.

An area of high pressure was north of the Lakes, and a trough of relatively low pressure extended from New Brunswick to the Gulf of Mexico.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Mar. 2.	*mm.*	*° C.*	%		*m. p. s.*	*m.*	*mm.*	*° C.*	%		*m. p. s.*
9:04 a. m...	716.9	9.2	100	wnw.	5.4	526	716.9	9.2	100	wnw.	5.4
9:19 a. m...	716.9	8.1	100	wnw.	6.7	733	699.3	8.9	......	wnw.	....
9:52 a. m....	716.9	7.6	100	nw.	8.5	1123	666.9	6.8	......	w.	....
10:05 a. m...	716.9	7.4	100	nw.	8.5	1497	637.2	3.8	......	w.	....
10:45 a. m...	717.0	7.5	100	nw.	6.7	2113	590.4	0.7	......	w.	....
12:49 p. m...	717.0	10.3	100	nw.	5.4	526	717.0	10.3	100	nw.	5.4
Mar. 3.											
8:14 a. m...	777.8	9.8	68	wsw.	4.0	526	717.8	9.8	68	wsw.	4.0
8:28 a. m...	717.8	10.3	65	w.	4.9	852	690.1	7.5	......	wsw.	....
8:46 a. m...	717.8	10.6	64	w.	4.5	1250	657.4	4.0	......	w.	....
8:59 a. m...	717.8	10.6	64	w.	4.5	1649	626.0	1.9	......	w.	....
9:03 a. m...	717.8	10.7	65	w.	4.9	1832	612.1	2.4	......	w.	....
9:24 a. m...	717.8	10.8	63	w.	4.9	2622	554.5	− 3.1	......	w.	....
9:32 a. m...	717.8	11.2	62	w.	4.9	2854	538.6	− 2.9	......	w.	....
10:08 a. m...	717.8	12.0	56	w.	7.2	3410	502.4	− 6.0	......	wnw.	....
10:57 a. m....	717.7	12.6	56	w.	8.0	3984	466.6	−10.0	......	w.	....
11:56 a. m....	717.5	13.4	56	w.	8.9	4687	426.1	−14.7	......	w.	....
1:07 p. m....	717.1	13.7	54	wnw.	6.7	3990	466.6	−10.4	......	wnw.	....
1:36 p. m....	716.9	14.6	50	wnw.	8.0	3418	502.4	− 6.3	......	w.	....
2:12 p. m....	716.7	14.6	48	wnw.	7.6	2864	538.6	− 1.2	......	w.	....
2:23 p. m....	716.7	14.8	49	wnw.	8.5	2661	552.6	− 2.5	......	w.	....
2:40 p. m....	716.6	14.5	41	wnw.	8.9	2036	596.8	0.4	......	w.	....
2:53 p. m....	716.6	14.6	41	wnw.	8.9	1274	655.2	7.2	......	wnw.	....
3:03 p. m....	716.6	14.3	41	wnw.	10.3	887	686.5	10.5	......	wnw.	....
3:16 p. m....	716.6	14.3	40	wnw.	10.7	526	716.6	14.3	40	wnw.	10.7
Mar. 4.											
4:33 p. m....	719.8	10.5	42	se.	4.9	526	719.8	10.5	42	se.	4.9
4:57 p. m....	719.8	10.3	40	se.	5.8	721	703.1	9.2	......	se.	....
5:57 p. m....	719.8	9.4	40	se.	5.8	902	687.9	7.7	......	s.	....
6:03 p. m....	719.8	9.4	40	se.	6.3	526	719.8	9.4	40	se.	6.3

March 2.—Three kites were used; lifting surface, 19.4 sq. m. Wire out, 4500 m., at maximum altitude.

There was dense fog. Light rain fell from 9:35 to 11 a. m.

Pressure was high over the Mississippi Valley, and was relatively low over Virginia.

March 3.—Seven kites were used; lifting surface, 45.1 sq. m. Wire out, 8500 m.; at maximum altitude, 8100 m.

Between 2/10 and 6/10 St.-Cu. from the west-northwest, and dense haze prevailed. The altitude of the clouds was about 1700 m.

At 8 a. m. high pressure was general in the Middle and Eastern States; low pressure was central over the Gulf of St. Lawrence.

March 4.—Three kites were used; lifting surface, 19.9 sq. m. Wire out, 2000 m.; at maximum altitude, 800 m.

There were from 1/10 to 4/10 Ci. from the west.

Pressure was high over West Virginia and low over southern Florida.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Mar. 5.	*mm.*	*° C.*	%		*m. p. s.*	*m.*	*mm.*	*° C.*	%		*m. p. s.*
7:14 a. m....	719.9	5.0	79	s.	8.9	526	719.9	5.0	79	s.	8.9
7:19 a. m....	719.9	5.2	75	s.	9.4	883	689.4	8.6	......	ssw.	....
7:45 a. m....	719.9	5.2	75	s.	8.9	1480	641.3	6.7	......	sw.	....
8:10 a. m....	719.9	5.2	73	sse.	8.0	1941	606.1	4.2	......	sw.	....
9:05 a. m....	719.9	5.9	73	sse.	9.4	2377	574.4	1.0	......	wsw.	....
9:44 a. m....	719.7	6.8	71	sse.	8.5	2872	539.9	− 1.4	......	wsw.	....
9:55 a. m....	719.6	7.2	66	sse.	8.9	4027	466.0	− 8.8	......	w.	....
10:41 a. m....	719.5	9.0	60	sse.	8.5	3398	505.6	− 5.6	......	w.	....
10:53 a. m....	719.4	9.8	53	se.	9.4	2782	546.5	− 0.8	......	wsw.	....
11:11 a. m....	719.3	10.2	51	se.	9.8	1942	606.1	5.1	......	wsw.	....
11:28 a. m....	719.2	10.8	45	sse.	10.3	1371	648.9	8.2	......	sw.	....
11:42 a. m....	719.0	10.8	44	sse.	10.7	921	685.8	9.6	......	sw.	....
11:48 a. m....	719.0	11.0	46	se.	13.4	526	719.0	11.0	46	se.	13.4
Mar. 6.											
2:30 p. m....	713.8	16.3	55	se.	7.6	526	713.8	16.3	55	se.	7.6
2:35 p. m....	713.8	16.5	54	se.	8.0	792	691.7	12.6	......	sse.	....
3:04 p. m....	713.6	17.0	54	se.	8.5	1178	660.7	14.1	......	ssw.	....
3:37 p. m....	713.1	16.5	58	se.	6.7	1756	616.2	8.5	......	sw.	....
4:07 p. m....	712.8	16.5	57	se.	7.6	2473	564.5	3.6	......	wsw.	....
4:41 p. m....	712.4	16.0	61	se.	8.5	3318	507.7	− 3.4	......	w.	....
5:13 p. m....	712.1	16.0	59	se.	8.9	2560	558.0	3.8	......	wsw.	....
5:23 p. m....	712.0	16.0	59	se.	8.9	1777	613.7	9.0	......	sw.	....
5:33 p. m....	711.8	16.0	58	se.	8.9	1205	656.8	13.4	......	ssw.	....
5:39 p. m....	711.7	15.9	58	se.	8.9	921	679.3	12.6	......	s.	....
5:51 p. m....	711.5	15.6	61	se.	8.9	526	711.5	15.6	61	se.	8.9
Mar. 7.											
2:55 p. m....	707.2	7.7	39	nw.	10.7	526	707.2	7.7	39	nw.	10.7
2:59 p. m....	707.2	7.6	39	nw.	13.4	787	685.1	2.9	......	nw.	....
3:12 p. m....	707.3	7.4	39	nw.	12.5	1190	651.7	− 0.6	......	nw.	....
3:34 p. m....	707.4	7.1	37	nw.	13.9	1598	619.4	− 3.7	......	wnw.	....
3:48 p. m....	707.4	6.5	41	nw.	13.9	2118	580.1	− 5.9	......	w.	....
4:06 p. m....	707.6	6.2	43	nw.	16.1	2924	522.0	−10.5	......	w.	....
4:45 p. m....	707.9	5.5	46	nw.	19.7	2434	556.4	− 8.1	......	w.	....
5:10 p. m....	708.1	5.0	46	nw.	17.0	2085	582.0	− 9.2	......	wnw.	....
5:25 p. m....	708.2	4.4	47	nw.	16.1	1772	605.7	− 6.6	......	wnw.	....
5:46 p. m....	708.4	4.0	50	nw.	14.3	1236	648.3	− 3.6	......	wnw.	....
6:04 p. m....	708.5	3.8	50	nw.	13.4	855	680.1	− 0.2	......	nw.	....
6:14 p. m....	708.6	3.5	51	nw.	13.4	526	708.6	3.5	51	nw.	13.4

March 5.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 8000 m.; at maximum altitude, 6000 m.

St.-Cu., from the west, slowly diminished from 7/10 to few. St.-Cu. passed under the head kite at 10:34 a. m.; altitude of kite, 3600 m.

High pressure, central over eastern Maryland, covered the country east of the Mississippi.

March 6.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 5200 m.; at maximum altitude, 4200 m.

3/10 to 8/10 Ci.-St. and A.-St. from the west prevailed.

At 8 a. m. pressure was high along the Atlantic coast and low north of Lake Superior.

March 7.—Four kites were used; lifting surface, 21.6 sq. m. Wire out, 4000 m.; at maximum altitude, 3900 m.

There were a few St.-Cu. from the west.

Low pressure was central over Ontario with a secondary depression over New Hampshire. High pressure was central over Oklahoma.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Mar. 8.	*mm.*	*° C.*	*%*		*m. p. s.*	*m.*	*mm.*	*° C.*	*%*		*m. p. s.*
6:54 a. m....	710.9	1.0	66	wnw.	6.7	526	710.9	1.0	66	wnw.	6.7
7:12 a. m....	711.0	1.2	63	wnw.	7.2	876	680.5	− 2.4	......	wnw.	....
7:27 a. m....	711.1	1.2	63	wnw.	7.6	1280	646.6	− 5.7	......	wnw.	....
7:42 a. m....	711.2	1.0	66	wnw.	7.2	1644	617.4	− 8.0	......	wnw.	....
7:55 a. m....	711.4	1.0	66	wnw.	7.2	2265	570.4	− 5.5	......	w.	....
8:13 a. m....	711.4	1.4	62	wnw.	3.6	2667	541.9	− 7.1	......	w.	....
8:44 a. m....	711.6	1.8	61	nw.	6.7	2876	527.8	− 6.0	......	wnw.	....
9:12 a. m....	711.7	2.0	60	nw.	8.0	3246	503.5	− 8.5	......	wnw.	....
10:43 a. m....	711.8	3.2	57	nw.	8.0	3762	471.1	−11.5	......	wnw.	....
11:01 a. m...	711.8	3.4	57	nw.	6.3	526	711.8	3.4	57	nw.	6.3
Mar. 9.											
7:26 a. m....	713.8	0.8	69	nw.	7.6	526	713.8	0.8	69	nw.	7.6
7:37 a. m....	714.0	1.2	66	nw.	7.6	907	680.9	− 0.3	......	wnw.	....
7:48 a. m...	714.0	1.2	66	nw.	7.6	1156	659.9	− 2.0	......	w.	....
8:09 a. m....	714.3	1.6	66	nw.	7.2	1600	624.1	− 5.6	......	w.	....
8:24 a. m....	714.4	2.2	64	nw.	7.2	1754	612.2	− 5.1	......	w.	....
8:52 a. m...	714.6	2.2	64	nw.	8.0	2574	551.6	− 6.1	......	w.	....
9:03 a. m....	714.7	2.5	64	nw.	7.2	2829	534.0	− 7.2	......	w.	....
9:45 a. m....	715.0	3.4	58	nw.	8.5	2440	561.3	− 7.4	......	w.	....
10:28 a. m....	715.2	4.5	56	nw.	8.0	2142	583.4	− 7.0	......	w.	....
10:47 a. m....	715.3	4.6	56	nw.	9.4	1693	617.9	− 4.8	......	w.	....
10:59 a. m....	715.3	4.6	56	nw.	8.0	1430	638.9	− 5.6	......	wnw.	....
11:15 a. m....	715.3	4.8	51	nw.	8.9	948	679.0	− 0.6	......	wnw.	....
11:24 a. m....	715.3	5.1	51	nw.	8.5	813	690.5	1.4	......	wnw.	....
11:32 a. m....	715.3	5.4	41	nw.	8.5	526	715.3	5.4	41	nw.	8.5
Mar. 10.											
7:20 a. m....	719.0	− 2.5	68	e.	8.0	526	719.0	− 2.5	68	e.	8.0
7:24 a. m....	719.0	− 2.6	70	e.	7.2	740	699.9	− 3.3	......	ese.	....
8:25 a. m....	719.2	− 2.7	72	e.	8.5	850	690.4	− 1.4	......	se.	....
9:25 a. m....	719.4	− 3.0	80	e.	8.5	1277	654.1	− 6.1	......	sse.	....
10:11 a. m....	719.4	− 3.2	91	ese.	6.7	1506	635.4	− 7.1	......	sse.	....
10:30 a. m....	719.3	− 3.6	100	ese.	6.7	960	680.8	− 3.6	......	s.	....
10:48 a. m....	719.2	− 3.8	100	ese.	7.6	526	719.2	− 3.8	100	ese.	7.6

March 8.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 8000 m.; at maximum altitude, 6900 m.

Between 2/10 and 3/10 St.-Cu. from the west-northwest prevailed.

At 8 a. m. pressure was high over the Gulf States and low over the St. Lawrence Valley.

March 9.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 5600 m., at maximum altitude.

There were a few Cu. from the west after 10:12 and from 4/10 to 7/10 Ci.-St. after 10:54 a. m. A solar halo was observed.

Pressure was low over the Gulf of St. Lawrence and high over Minnesota.

March 10.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 4000 m.; at maximum altitude, 2500 m.

At the beginning the sky was covered with A.-St., from the west-southwest. The cloud cover gradually became lower until 10:30 a. m., when low St. from the east-southeast rapidly overspread the sky. Snow fell after 7:30 a. m.

A ridge of high pressure extended from New York to Oklahoma. Pressure was relatively low over the Gulf and off the Carolina coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910											
Mar. 11.	*mm.*	*°C.*	%		*m. p. s.*	*m.*	*mm.*	*°C.*	%		*m. p. s.*
3:04 p. m....	718.0	− 0.8	92	se.	5.4	526	718.0	− 0.8	92	se.	5.4
3:47 p. m....	718.0	− 0.8	92	se.	7.6	787	694.9	− 3.7	......	sse.	....
4:17 p. m....	718.0	− 1.0	92	se.	7.6	1030	673.9	− 1.3	......	s.	....
4:33 p. m....	718.0	− 1.2	92	se.	8.5	1415	641.8	− 5.4	......	ssw.	....
5:48 p. m....	717.8	− 1.5	99	se.	8.9	1680	620.4	− 7.5	......	sw.	....
5:51 p. m....	717.8	− 1.5	100	se.	8.9	1832	608.3	− 5.2	......	sw.	....
5:53 p. m....	717.8	− 1.5	100	se.	8.9	1678	620.4	− 7.5	......	sw.	....
6:02 p. m....	717.8	− 1.6	100	se.	8.5	1482	636.1	− 6.3	......	wsw.	....
6:11 p. m....	717.8	− 1.7	100	se.	8.5	1186	660.5	− 3.5	......	sw.	....
6:15 p. m....	717.8	− 1.7	100	se.	8.5	894	685.3	− 2.2	......	sw.	....
6:17 p. m....	717.7	− 1.6	100	se.	8.5	740	698.7	− 3.6	......	sw.	....
6:21 p. m....	717.7	− 1.6	100	se.	7.6	526	717.7	− 1.6	100	se.	7.6
Mar. 12.											
1:23 p. m....	715.8	2.0	71	nnw.	4.5	526	715.8	2.0	71	nnw.	4.5
2:02 p. m....	715.2	2.5	68	nnw.	5.8	926	680.5	− 1.8	......	n.	....
2:12 p. m....	715.1	2.6	68	nnw.	6.7	1273	651.4	− 3.1	......	n.	....
2:34 p. m....	715.0	2.7	69	nnw.	6.3	1543	629.6	− 1.6	......	nne.	....
3:44 p. m....	714.5	3.0	72	nnw.	7.6	1737	614.0	− 2.4	......	nne.	....
3:52 p. m....	714.5	2.8	72	nnw.	8.0	2478	558.8	− 7.0	......	nne.	....
3:58 p. m....	714.4	2.8	72	nnw.	8.5	2160	582.7	− 5.3	......	nne.	....
4:18 p. m....	714.3	2.8	71	nw.	8.9	1861	604.3	− 3.1	......	n.	....
4:25 p. m....	714.3	2.8	71	nw.	8.5	1362	643.5	− 1.0	......	n.	....
4:35 p. m....	714.3	2.9	71	nw.	7.6	1109	664.2	− 2.4	......	nnw.	....
4:42 p. m....	714.3	3.0	69	nw.	5.4	874	684.1	− 0.5	......	nnw.	....
4:47 p. m....	714.2	3.0	69	nw.	5.4	526	714.2	3.0	69	nw.	5.4
Mar. 13.											
8:26 a. m....	710.6	5.6	52	w.	6.7	526	710.6	5.6	52	w.	6.7
8:37 a. m....	710.6	6.1	50	w.	8.5	882	680.3	4.0	......	w.	....
8:49 a. m....	710.5	6.3	50	w.	7.2	1343	642.5	0.5	......	w.	....
9:08 a. m....	710.4	6.6	50	w.	7.6	1538	627.1	4.9	......	wnw.	....
9:35 a. m....	710.0	7.2	50	w.	9.4	2252	574.0	0.1	......	wnw.	....
9:55 a. m....	709.8	7.4	50	w.	8.5	2563	551.9	− 1.9	......	wnw.	....
10:04 a. m....	709.7	7.6	51	w.	8.0	3238	507.0	− 5.5	......	w.	....
10:35 a. m....	709.1	8.7	49	w.	9.8	2304	570.2	0.4	......	wsw.	....
10:53 a. m....	708.8	9.2	45	w.	8.9	1843	603.4	3.6	......	w.	....
11:08 a. m....	708.6	10.0	45	sw.	8.9	1382	638.6	5.0	......	w.	....
11:15 a. m....	708.5	10.2	45	sw.	7.6	1256	648.1	4.5	......	sw.	....
11:23 a. m....	708.4	10.0	45	sw.	8.0	800	685.3	6.1	......	sw..	....
11:28 a. m....	708.3	10.4	42	sw.	8.0	526	708.3	10.4	42	sw.	8.0

March 11.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 3900 m.; at maximum altitude, 2000 m.

About 4/10 St. from the southwest and 6/10 St. from the southeast were present. The base of the lower clouds at times extended to the ground.

Centers of low pressure were over Wisconsin and Georgia. High pressure was central over Maine.

March 12.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 3500 m.; at maximum altitude, 2700 m.

There were 6/10 A.-Cu. from the south and 2/10 St. from the north. The head kite was in the clouds at frequent intervals from 3:03 to 3:46 p. m.

Pressure was low off the Carolina coast and high over Maine.

March 13.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 5000 m.; at maximum altitude, 4250 m.

There were a few Ci.-Cu. from the west.

Pressure was low over Ontario and high over North Dakota.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Mar. 14.	*mm.*	*°C.*	%		*m. p. s.*	*m.*	*mm.*	*°C.*	%		*m. p. s.*
1:36 p. m....	709.5	− 0.6	41	nw.	17.9	526	709.5	− 0.6	41	nw.	17.9
1:45 p. m....	709.5	− 0.8	47	wnw.	15.6	793	685.2	− 4.9	......	nw.	....
1:56 p. m....	709.5	− 0.8	41	nw.	21.5	1034	664.4	− 6.7	......	nw.	....
2:09 p. m....	709.6	0.0	46	wnw.	17.4	1497	627.0	−10.7	......	nw.	....
2:21 p. m....	709.6	0.4	44	wnw.	18.8	1526	624.8	− 7.6	......	nw.	....
2:46 p. m....	709.8	− 0.1	50	wnw.	23.2	2102	580.1	−10.0	......	nw.	....
3:20 p. m....	709.9	− 0.6	52	nw.	17.0	1676	613.0	−11.4	......	nw.	....
3:41 p. m....	709.8	− 1.0	50	wnw.	18.8	1047	664.4	− 7.4	......	nw.	....
3:49 p. m....	709.8	− 0.6	51	nw.	19.7	806	685.2	− 5.1	......	nw.	....
3:57 p. m....	709.8	− 1.0	47	nw.	19.7	526	709.8	− 1.0	47	nw.	19.7
Mar. 15.											
10:05 a. m...	715.4	− 4.2	64	wnw.	14.8	526	715.4	− 4.2	64	wnw.	14.8
10:24 a. m....	715.5	− 3.7	57	wnw.	14.8	1167	659.1	−10.2	......	nw.	....
10:28 a. m....	715.5	− 3.7	57	wnw.	14.3	1301	647.7	− 6.7	......	nw.	....
11:18 a. m....	715.6	− 2.9	57	nw.	14.3	2453	558.3	−11.7	....	nnw.	....
11:34 a. m....	715.6	− 2.4	58	nw.	14.3	1681	616.4	− 8.0	......	nnw.	....
12:34 p. m....	715.4	− 1.2	58	nw.	13.4	2889	527.4	−13.9	......	nnw.	....
1:24 p. m....	715.1	− 1.0	55	nw.	13.4	2313	568.5	−10.2	......	nw.	....
1:45 p. m....	715.0	− 0.3	53	nw.	13.4	1689	616.4	− 8.4	......	nw.	....
1:53 p. m....	714.9	− 0.1	56	nw.	13.4	1546	627.9	−10.6	......	nw.	....
2:03 p. m....	714.9	− 0.2	50	nw.	13.4	1011	672.3	− 7.2	......	nw.	....
2:17 p. m...	714.9	0.1	52	nw.	12.5	526	714.9	0.1	52	nw.	12.5
Mar. 16.											
8:35 a. m....	714.5	− 0.6	51	wnw.	16.1	526	714.5	− 0.6	51	wnw.	16.1
8:39 a. m....	714.5	− 0.7	52	wnw.	13.4	876	683.8	− 2.9	......	wnw.	....
8:52 a. m....	714.5	− 0.6	48	w.	15.2	1183	657.9	− 0.6	......	wnw.	....
9:07 a. m....	714.4	0.1	54	wnw.	15.2	1512	631.4	0.8	......	wnw.	....
10:11 a. m....	714.0	2.0	40	wnw.	12.5	2226	576.9	− 5.2	......	nw.	....
10:46 a. m....	714.0	2.2	43	wnw.	12.5	2998	522.4	− 9.6	......	nw.	....
11:56 a. m....	713.8	4.5	40	wnw.	11.6	3250	505.5	−11.9	......	nw.	....
12:20 p. m....	713.7	4.6	41	wnw.	11.6	3842	467.6	−13.9	......	wnw.	....
1:21 p. m....	713.5	4.2	47	wnw.	11.6	3246	505.5	−11.9	......	wnw.	....
1:33 p. m....	713.4	5.2	33	wnw.	11.6	2334	568.7	− 6.2	......	nw.	....
1:49 p. m....	713.3	6.0	32	wnw.	12.1	1527	629.6	0.2	......	nw.	....
1:59 p. m....	713.2	6.6	32	w.	12.1	1432	637.1	− 3.9	......	w.	....
2:17 p. m....	713.2	6.3	32	w.	13.4	788	690.6	2.1	......	w.	....
2:22 p. m....	713.2	6.2	34	wnw.	13.4	526	713.2	6.2	34	wnw.	13.4

March 14.—Three kites were used; lifting surface, 16.2 sq. m. Wire out, 5000 m.; at maximum altitude, 4300 m.

There were about 5/10 St.-Cu. from the northwest.

Low pressure was central over Maine, high pressure over Minnesota.

March 15.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 6000 m.; at maximum altitude, 4800 m.

There were about 4/10 St.-Cu. from the northwest, their altitude increasing from 1300 m. to 1700 m. during the flight.

At 8 a. m. pressure was high over the middle Mississippi Valley and low north of Lake Superior and over the Gulf of St. Lawrence.

March 16.—Eight kites were used; lifting surface, 50.4 sq. m. Wire out, 12500 m.; at maximum altitude, 10750 m.

5/10 to 7/10 Ci. from the west, and from 1/10 to 3/10 St.-Cu. from the northwest were present.

Low pressure was central over the lower St. Lawrence Valley. Pressure was high over Mississippi and Alabama.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. Mar. 23.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
4:56 p. m....	718.0	21.4	43	se.	7.2	526	718.0	21.4	43	se.	7.2
5:47 p. m....	718.2	20.6	40	se.	5.4	926	685.6	16.5	......	sse.	....
6:45 p. m....	718.5	19.4	45	se.	4.5	1382	649.8	12.1	......	s.	....
6:59 p. m....	718.6	18.6	47	ese.	4.9	1919	609.2	7.7	......	ssw.	....
7:07 p. m....	718.7	17.3	55	ese.	4.9	1584	634.3	10.6	......	s.	....
7:14 p. m....	718.7	16.8	58	ese.	4.9	1092	672.3	14.0	......	sse.	....
7:25 p. m....	718.8	16.5	59	ese.	4.5	773	698.2	15.9	......	se.	....
7:30 p. m....	718.8	16.8	58	ese.	4.9	526	718.8	16.8	58	ese.	4.9
Mar. 24.											
7:44 a. m....	720.6	7.4	92	wnw.	4.9	526	720.6	7.4	92	wnw.	4.9
8:02 a. m....	720.6	7.6	94	wnw.	5.4	990	681.9	16.8	......	sw.	....
8:18 a. m....	720.6	7.8	93	wnw.	5.4	1464	644.9	13.9	......	sw.	....
9:27 a. m....	720.5	9.7	85	wnw.	3.1	2044	602.0	9.8	......	w.	....
10:18 a. m....	720.3	13.1	71	wsw.	1.3	2736	553.7	4.3	......	wsw.	....
10:32 a. m....	720.2	14.1	68	calm.	0.0	2323	582.2	7.5	......	wsw.	....
10:42 a. m....	720.2	14.2	65	wnw.	1.8	1936	610.0	10.2	......	wsw.	....
10:51 a. m....	720.1	14.4	66	wnw.	3.6	1291	658.4	15.2	......	wsw.	....
11:03 a. m....	720.1	15.4	64	wnw.	1.8	781	699.0	18.5	......	sw.	....
11:08 a. m....	720.1	16.0	61	calm.	0.0	526	720.1	16.0	61	calm.	0.0
Mar. 25.											
8:25 a. m....	716.3	17.4	53	w.	8.0	526	716.3	17.4	53	w.	8.0
8:32 a. m....	716.3	17.5	52	w.	7.6	962	680.7	16.5	......	wnw.	....
8:46 a. m....	716.3	17.6	54	wnw.	7.6	1167	664.6	15.0	......	wnw.	....
9:16 a. m....	716.3	18.4	48	wnw.	8.9	2119	593.6	10.2	......	w.	....
9:46 a. m....	716.3	19.6	46	wnw.	8.5	2847	543.2	4.0	......	w.	....
10:44 a. m....	716.3	20.1	35	wnw.	6.7	3349	510.5	0.0	......	w.	....
11:59 a. m....	716.0	22.1	28	w.	6.3	4080	466.4	− 2.1	......	w.	....
12:40 p. m....	715.7	22.6	31	nw.	6.3	4499	442.4	− 6.5	......	w.	....
1:29 p. m....	715.3	23.2	35	wnw.	6.3	5166	405.6	−11.4	......	w.	....
1:58 p. m....	715.0	24.0	30	w.	7.2	4862	422.3	−10.3	......	w.	....
3:11 p. m....	714.5	24.2	21	wnw.	11.2	2368	575.6	7.2	......	w.	....
3:42 p. m....	714.3	24.4	19	wnw.	14.8	965	677.1	19.2	......	w.	....
3:50 p. m....	714.3	24.4	13	wnw.	12.5	526	714.3	24.4	13	wnw.	12.5

March 23.—Four kites were used; lifting surface, 31.1 sq. m. Wire out, 2700 m.; at maximum altitude, 1700 m.

There were a few Cu. from the west.

Pressure was high over Ontario and off the south Atlantic coast.

March 24.—Five kites were used; lifting surface, 32.5 sq. m. Wire out, 3500 m.; at maximum altitude, 2900 m.

A.-Cu. from the west increased from 4/10 to 7/10 by 8:15 a. m., and diminished to none by 10:15 a. m. There was light haze.

At 8 a. m. pressure was high along the Atlantic coast and low over Manitoba and western Ontario.

March 25.—Seven kites were used; lifting surface, 44.1 sq. m. Wire out, 12500 m.; at maximum altitude, 11500 m.

There were 6/10 to a few A.-Cu. from the west accompanied by dense haze.

Pressure was low over Maine and high over Georgia.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
Mar. 26.	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	°*C.*	%		*m. p. s.*
7:02 a. m....	718.5	10.7	45	nw.	8.9	526	718.5	10.7	45	nw.	8.9
7:10 a. m....	718.6	10.6	45	nw.	7.6	881	688.7	9.6	......	nnw.	....
7:16 a. m....	718.6	10.7	44	nw.	8.0	987	680.0	11.9	......	n.	....
7:25 a. m....	718.6	10.8	44	nw.	7.6	1307	654.3	9.5	......	n.	....
8:31 a. m....	719.1	11.5	43	w.	8.0	1663	627.3	7.4	......	n.	....
9:15 a. m....	719.5	12.0	42	wnw.	7.6	2167	590.3	4.8	......	nnw.	....
9:40 a. m....	719.6	13.0	38	wnw.	4.9	526	719.6	13.0	38	wnw.	4.9
Mar. 27.											
6:55 a. m....	721.6	6.6	59	e.	8.0	526	721.6	6.6	59	e.	8.0
8:28 a. m....	722.0	7.0	60	ese.	9.4	682	706.7	15.9	......	sse.	....
9:01 a. m....	722.1	7.4	62	ese.	9.4	948	686.7	10.4	......	se.	....
9:31 a. m....	722.2	8.0	60	ese.	9.4	845	695.2	14.8	......	sse.	....
9:40 a. m....	722.2	8.4	59	ese.	8.9	526	722.2	8.4	59	ese.	8.9
Mar. 28.											
9:13 a. m....	721.0	14.8	51	wsw.	7.2	526	721.0	14.8	51	wsw.	7.2
9:24 a. m....	720.9	15.3	48	wsw.	7.6	835	695.4	19.3	......	w.	....
9:36 a. m....	720.9	15.5	48	wsw.	7.2	1430	648.7	15.2	......	wnw.	....
9:47 a. m....	720.8	16.6	45	wsw.	7.6	1976	608.1	11.2	......	wnw.	....
10:01 a. m....	720.8	17.1	45	wsw.	7.2	2637	562.0	8.1	......	wnw.	....
10:13 a. m....	720.8	17.5	45	wsw.	6.3	3116	530.3	4.4	......	wnw.	....
10:43 a. m....	720.7	18.5	44	w.	4.9	3629	497.8	1.0	......	w.	....
12:20 p. m....	720.3	22.6	42	se.	3.1	4249	460.1	− 5.4	......	w.	....
1:23 p. m....	719.9	22.2	42	se.	2.2	5001	417.8	−10.9	......	w.	....
2:15 p. m....	719.6	21.0	44	se.	4.0	4022	473.6	− 3.1	......	w.	....
2:41 p. m....	719.4	21.0	44	se.	4.5	3289	519.0	3.2	......	w.	....
2:58 p. m....	719.3	22.8	41	se.	4.5	2745	554.5	7.2	......	w.	....
3:16 p. m....	719.2	22.8	41	se.	3.6	2086	600.1	12.7	......	w.	....
3:26 p. m....	719.2	22.6	42	se.	4.0	1499	643.0	17.2	......	w.	....
3:37 p. m....	719.2	22.6	42	sse.	4.0	938	686.1	22.5	......	wsw.	....
3:46 p. m....	719.1	22.6	42	sse.	4.5	526	719.1	22.6	42	sse.	4.5

March 26.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 3050 m.; at maximum altitude, 2740 m.

The sky was nearly covered with A.-St., from the west-northwest, accompanied by 1/10 Ci.-St. after 8:30 a. m., from the northwest.

Pressure was low over New Brunswick, and high over the Lake region and West Virginia.

March 27.—Four kites were used; lifting surface, 26.7 sq. m. Wire out, 2800 m.; at maximum altitude, 2500 m.

There were a few Ci.-Cu. from the west.

High pressure was central over the St. Lawrence Valley. Low pressure was central over North Dakota.

March 28.—Six kites were used; lifting surface, 38.8 sq. m. Wire out, 9500 m.; at maximum altitude, 8500 m.

A few Ci.-Cu. from the west increased to 5/10 by the end of the flight.

High pressure, central off the coast of New England, extended southward along the Atlantic coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.	mm.	°C.	%		m. p. s.	m.	mm.	°C.	%		m. p. s.
Mar. 29.											
2:27 p. m....	722.2	23.6	36	sse.	6.3	526	722.2	23.6	36	sse.	6.3
3:07 p. m....	722.1	23.8	36	s.	6.7	735	705.1	21.8	......	s.	......
4:26 p. m....	721.9	22.5	34	s.	5.8	964	686.5	21.5	......	ssw.	......
4:44 p. m....	721.8	22.3	35	s.	6.3	793	700.0	22.5	......	s.	......
4:52 p. m....	721.7	22.2	33	s.	6.3	526	721.7	22.2	33	s.	6.3
Mar. 30.											
6:56 a. m....	721.9	19.8	49	w.	5.4	526	721.9	19.8	49	w.	5.4
9:03 a. m....	721.7	21.3	47	w.	6.7	725	705.4	22.4	......	w.	......
10:20 a. m....	721.5	22.6	47	w.	9.8	1044	679.8	19.8	......	wnw.	......
11:05 a. m....	721.3	23.7	47	wnw.	9.4	1182	669.0	27.6	......	wnw.	......
11:11 a. m....	721.3	23.6	43	w.	9.8	1513	644.4	25.1	......	wnw.	......
11:16 a. m....	721.2	24.0	43	w.	9.8	1160	670.7	20.8	......	wnw.	......
11:28 a. m....	721.2	23.9	43	w.	8.5	783	700.3	21.6	......	wnw.	......
11:35 a. m....	721.2	24.2	41	wnw.	8.9	526	721.2	24.2	41	wnw.	8.9
Mar. 31.											
5:23 p. m....	719.8	20.4	52	nw.	4.9	526	719.8	20.4	52	nw.	4.9
5:29 p. m....	719.8	20.4	51	nw.	6.3	897	680.5	17.4	......	nw.	......
5:40 p. m....	719.9	20.2	52	nw.	7.6	1309	656.8	13.1	......	wnw.	......
5:51 p. m....	720.0	20.2	52	nw.	8.9	1848	616.0	8.3	......	wnw.	......
6:02 p. m....	720.0	19.9	52	nw.	13.0	2421	574.7	4.9	......	wnw.	......
6:17 p. m....	720.1	19.7	50	nw.	13.4	3038	532.7	0.6	......	w.	......
6:29 p. m....	720.1	19.4	51	nw.	13.9	3572	498.4	−3.1	......	w.	......
6:47 p. m....	720.3	18.2	56	nw.	13.9	3036	532.7	0.9	......	w.	......
7:07 p. m....	720.3	17.7	57	nw.	13.9	2421	574.7	5.9	......	w.	......
7:32 p. m....	720.5	17.3	56	nw.	13.9	1847	616.0	8.9	......	wnw.	......
7:50 p. m....	720.6	17.4	52	nw.	12.5	1407	649.4	11.3	......	wnw.	......
8:14 p. m....	721.1	17.4	51	wnw.	13.0	867	692.9	14.4	......	wnw.	......
8:22 p. m....	721.1	17.1	53	wnw.	10.7	526	721.1	17.1	53	wnw.	10.7

March 29.—Four kites were used; lifting surface, 26.2 sq. m. Wire out, 2300 m.; at maximum altitude, 1600 m.

There were 6/10 to 8/10 St. from the southwest, accompanied by dense haze.

Pressure was low over New Brunswick and high over Georgia and the Carolinas

March 30.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 4500 m.; at maximum altitude, 1650 m.

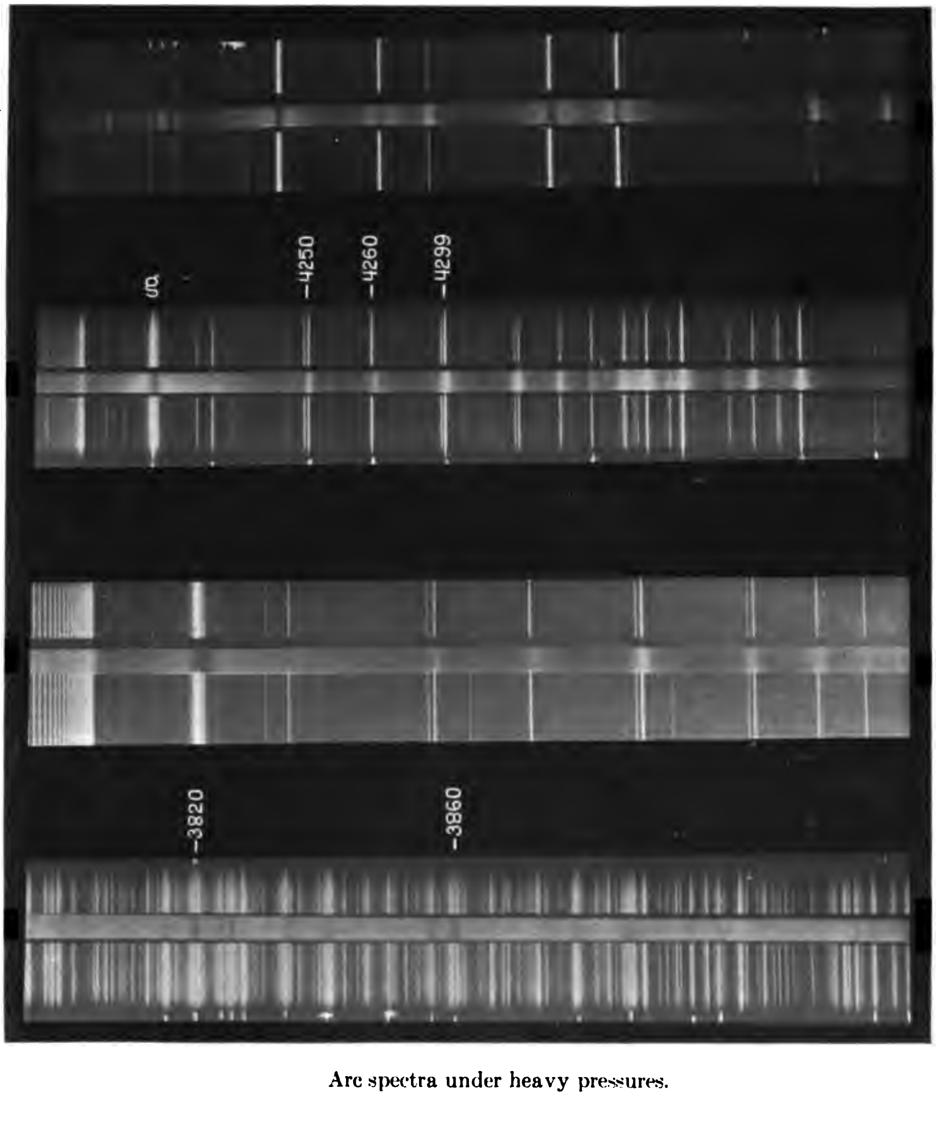
There was dense haze.

Low pressure was central over Minnesota. Centers of high pressure lay over the South Atlantic States and the Gulf of St. Lawrence.

March 31.—Three kites were used; lifting surface, 23.8 sq. m. Wire out, 5000 m.; at maximum altitude, 4770 m.

There were 8/10 to 10/10 St.-Cu. from the west and light haze. The base of the clouds was about 3400 m. above sea level.

At 8 a. m. pressure was high over Colorado, New Mexico, and northern Texas, and off the New England and Florida coasts; it was low over southern Texas and north of the Lake region.



Arc spectra under heavy pressures.

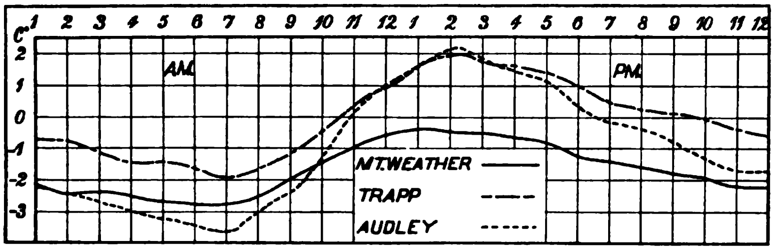


FIG. 1.—Mean hourly temperatures, January, 1910.

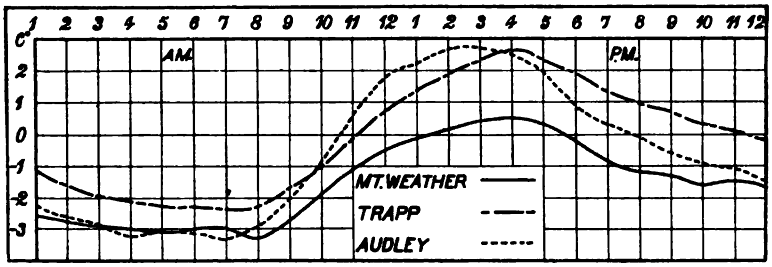


FIG. 2.—Mean hourly temperatures, February, 1910.

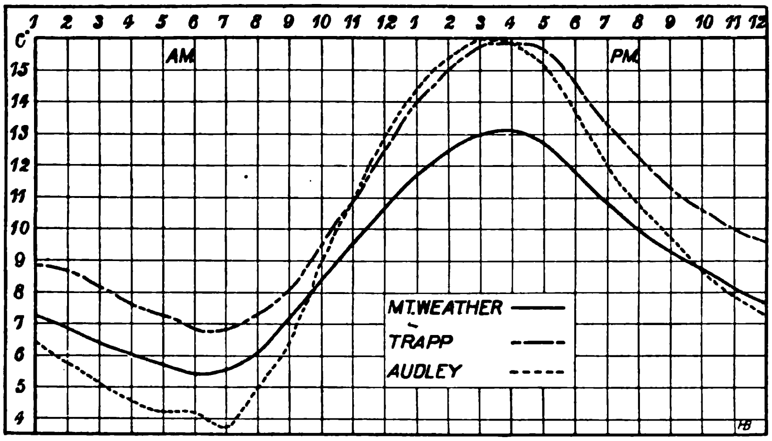
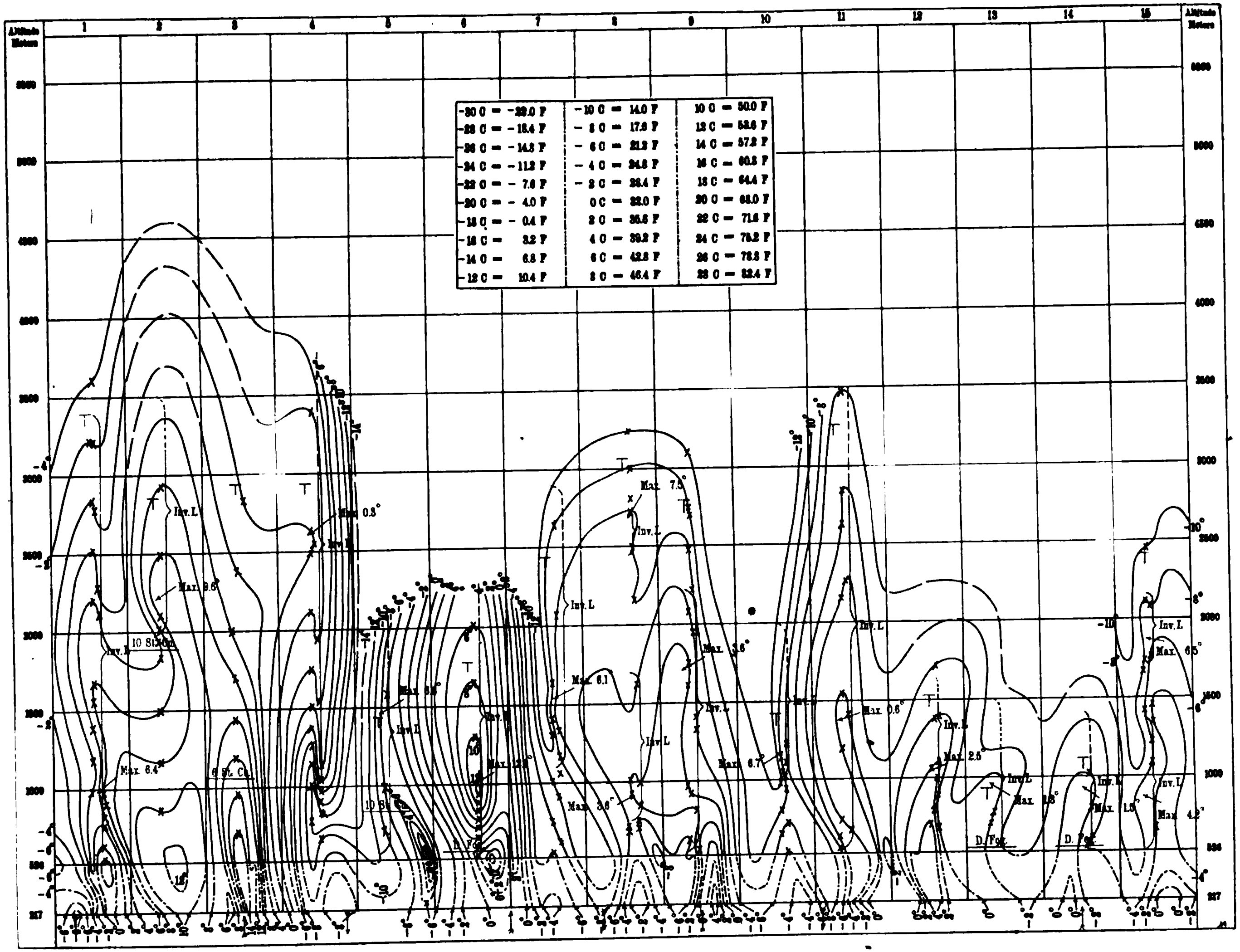
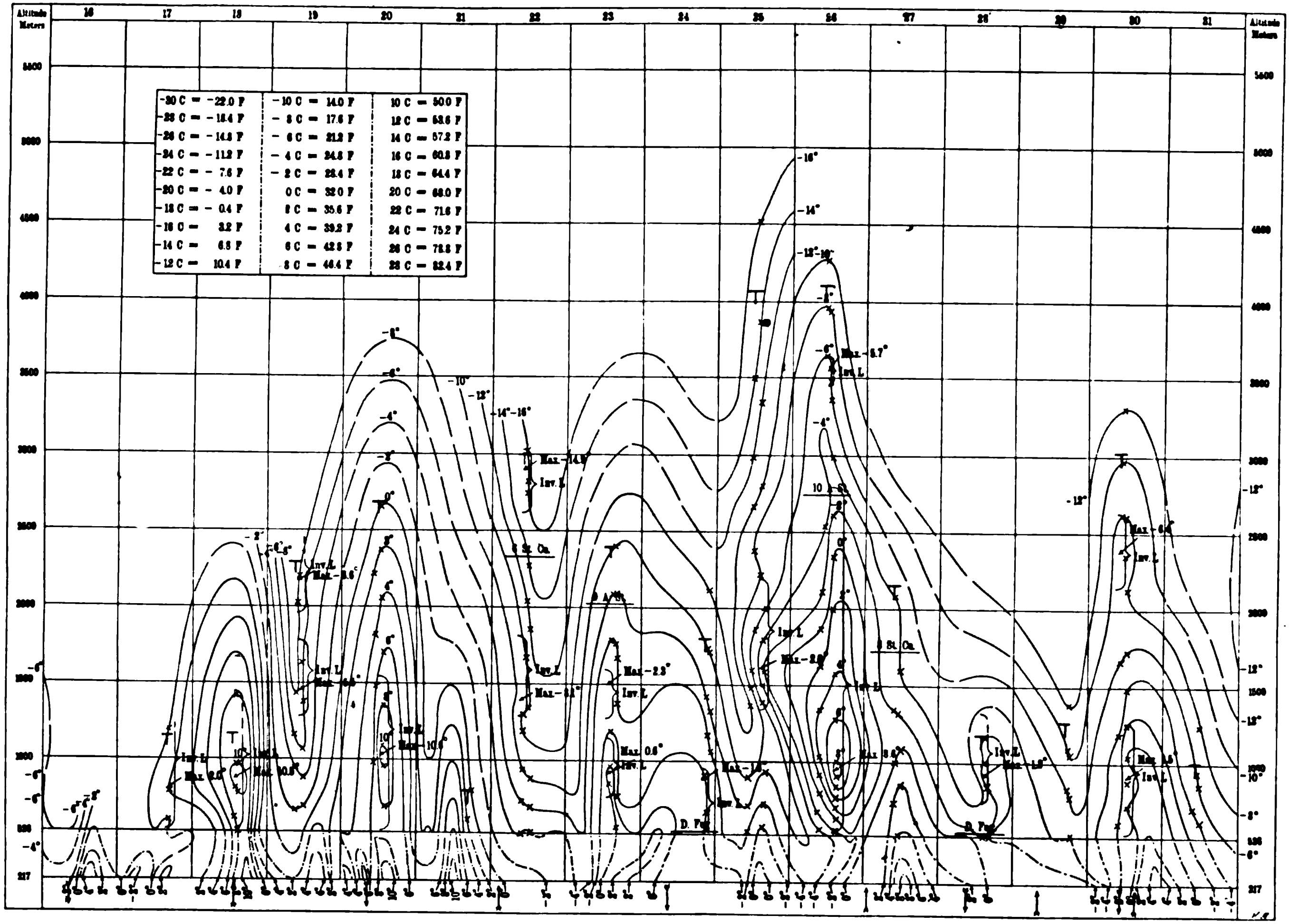


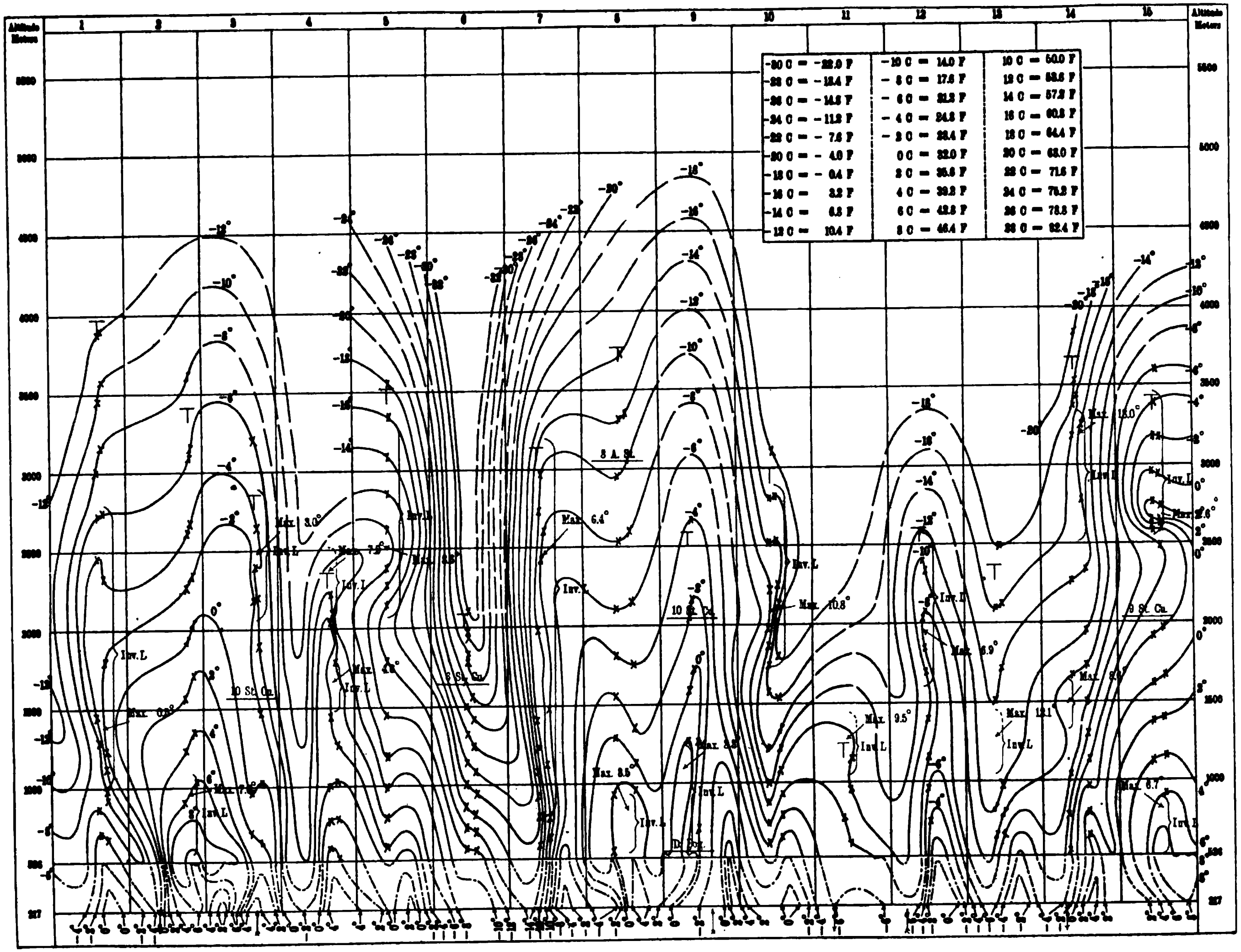
FIG. 3.—Mean hourly temperatures, March, 1910.



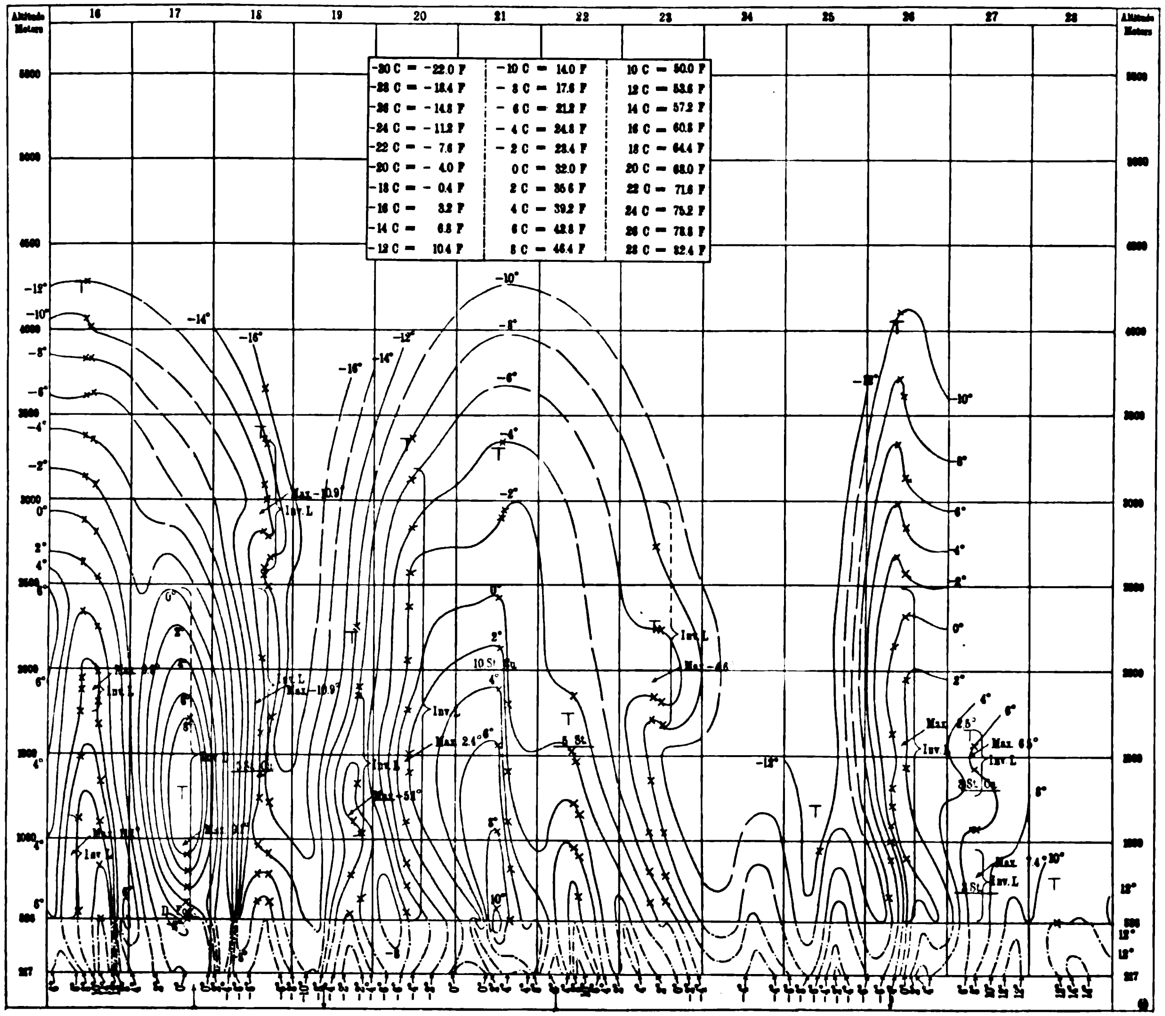
Free air isotherms, January 1-15, 1910.



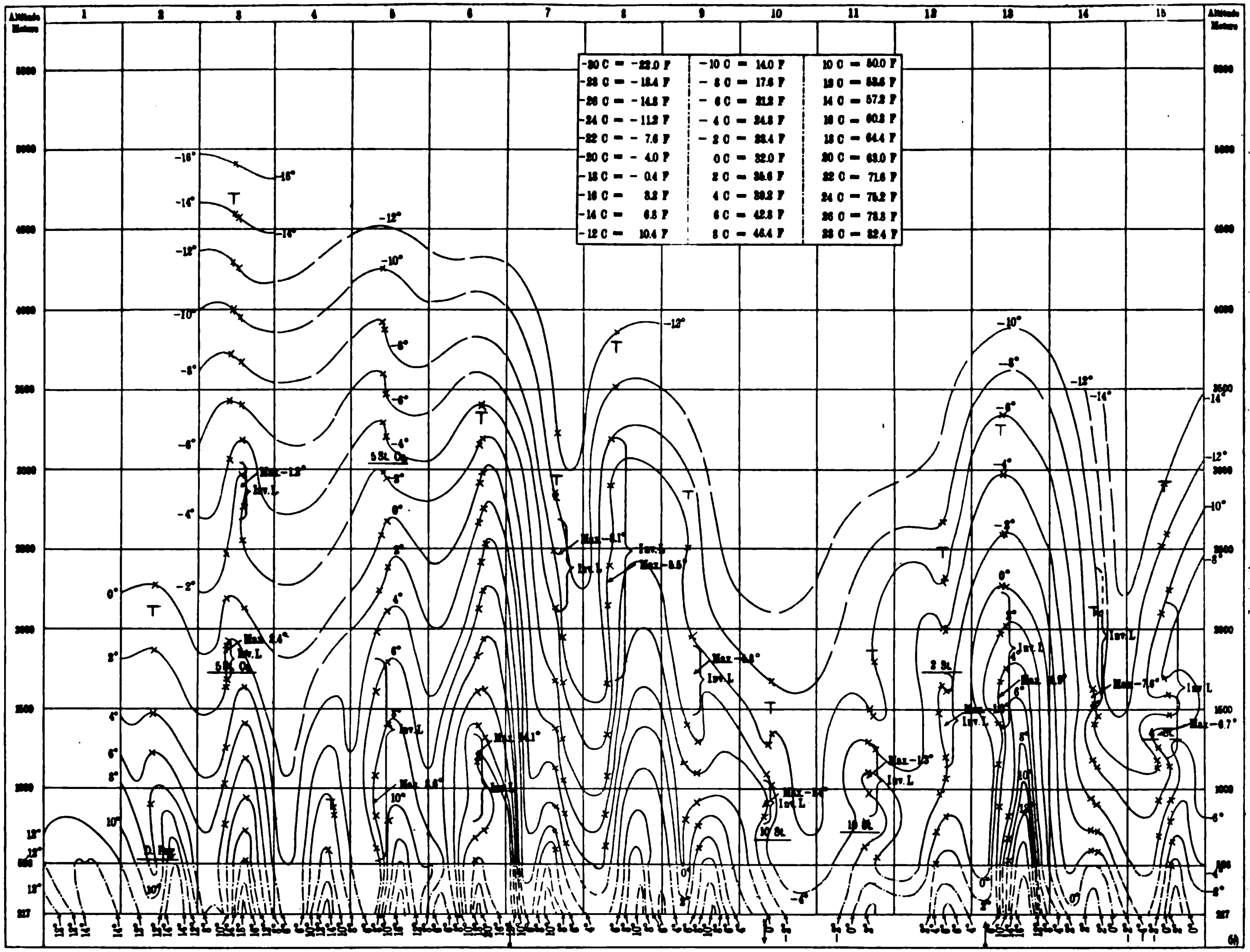
Free air isotherms, January 16–31, 1910.



Free air isotherms, February 1–15, 1910.



Free air isotherms, February 16–28, 1910.



Free air isotherms, March 1-15, 1910.

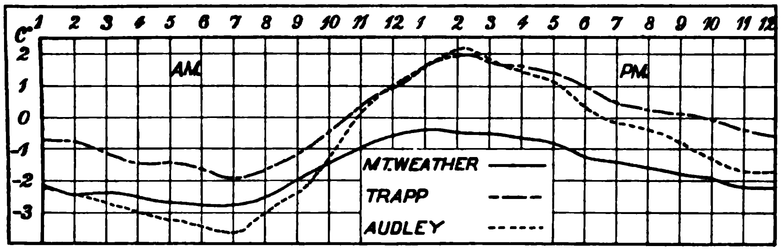


FIG. 1.—Mean hourly temperatures, January, 1910.

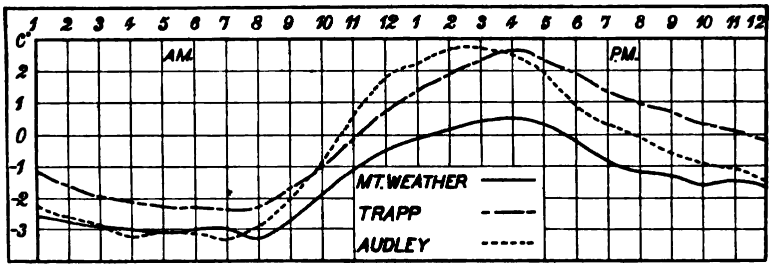


FIG. 2.—Mean hourly temperatures, February, 1910.

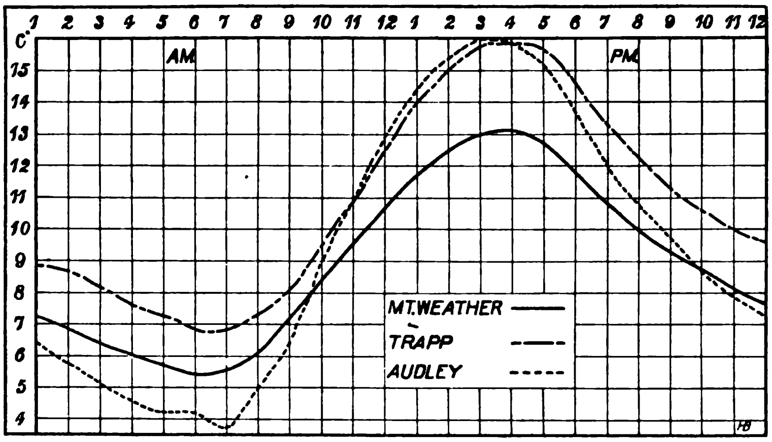
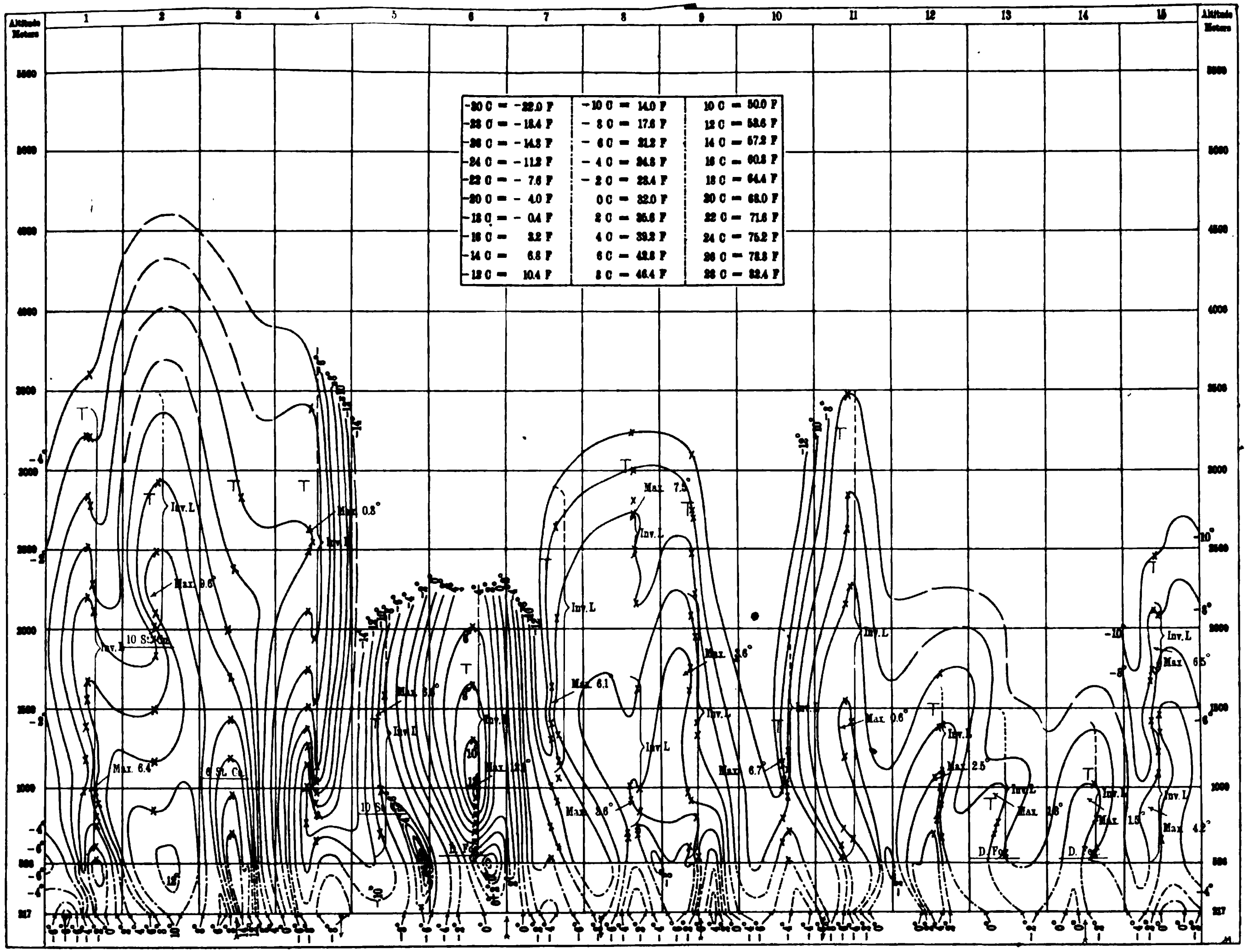
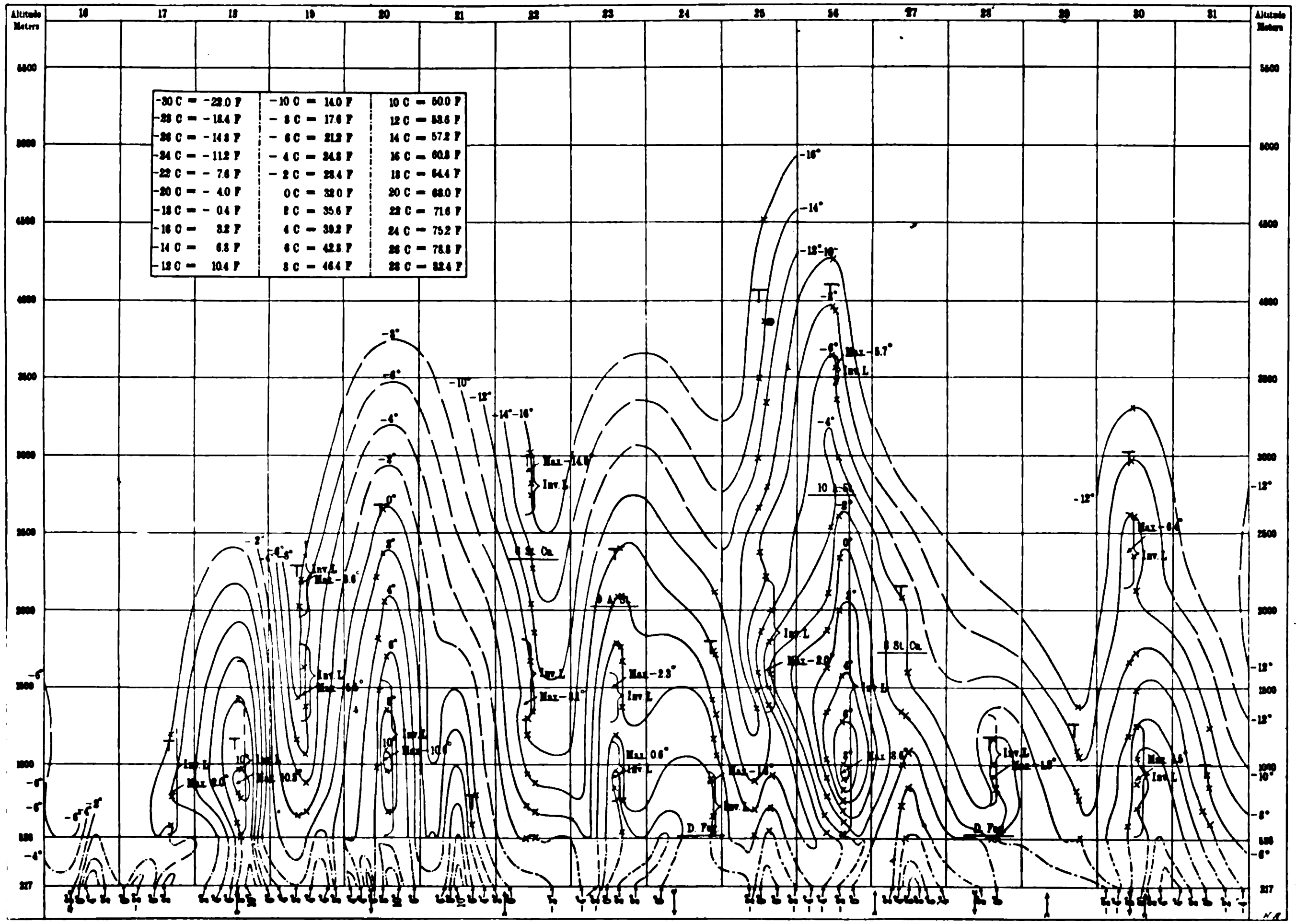


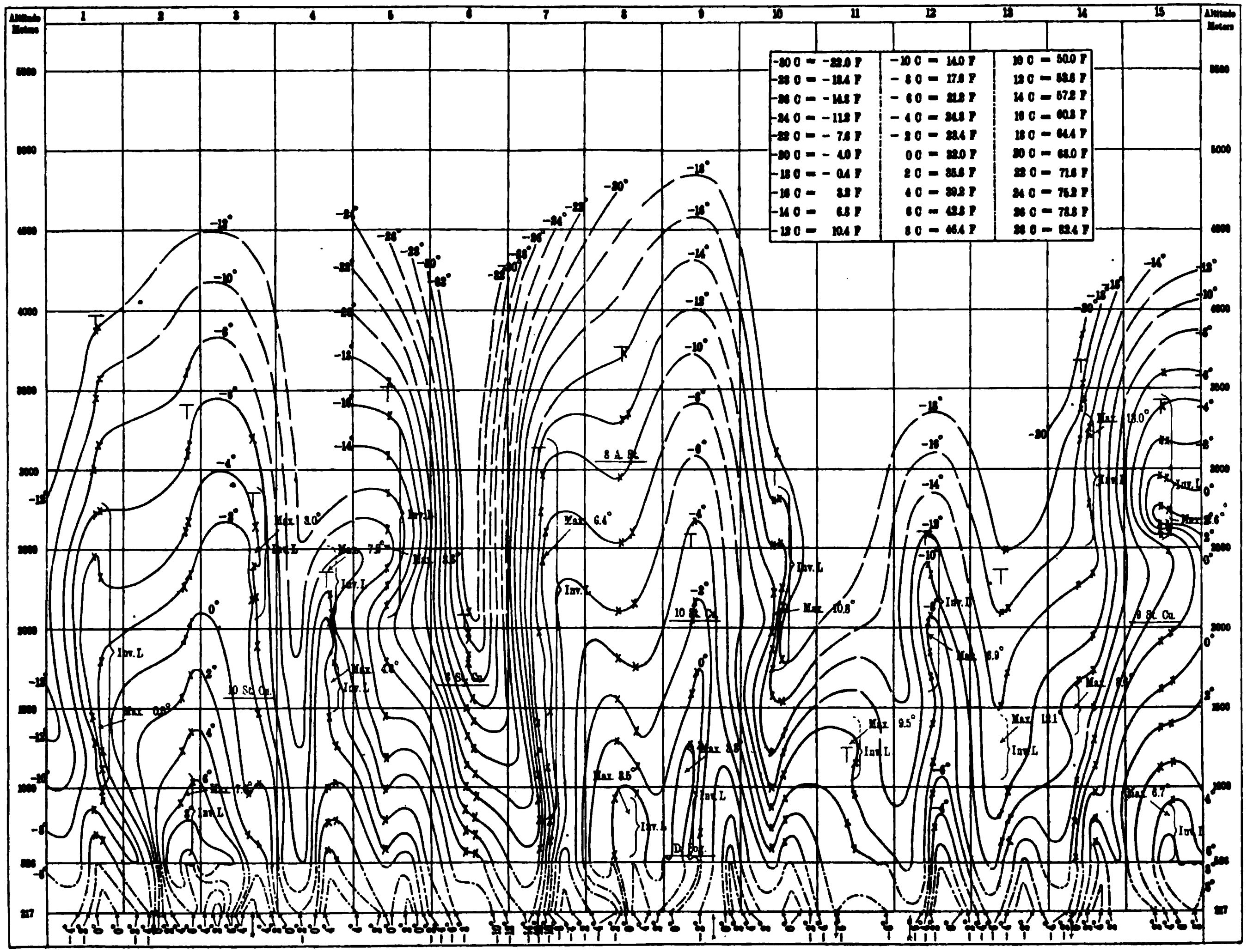
FIG. 3.—Mean hourly temperatures, March, 1910.



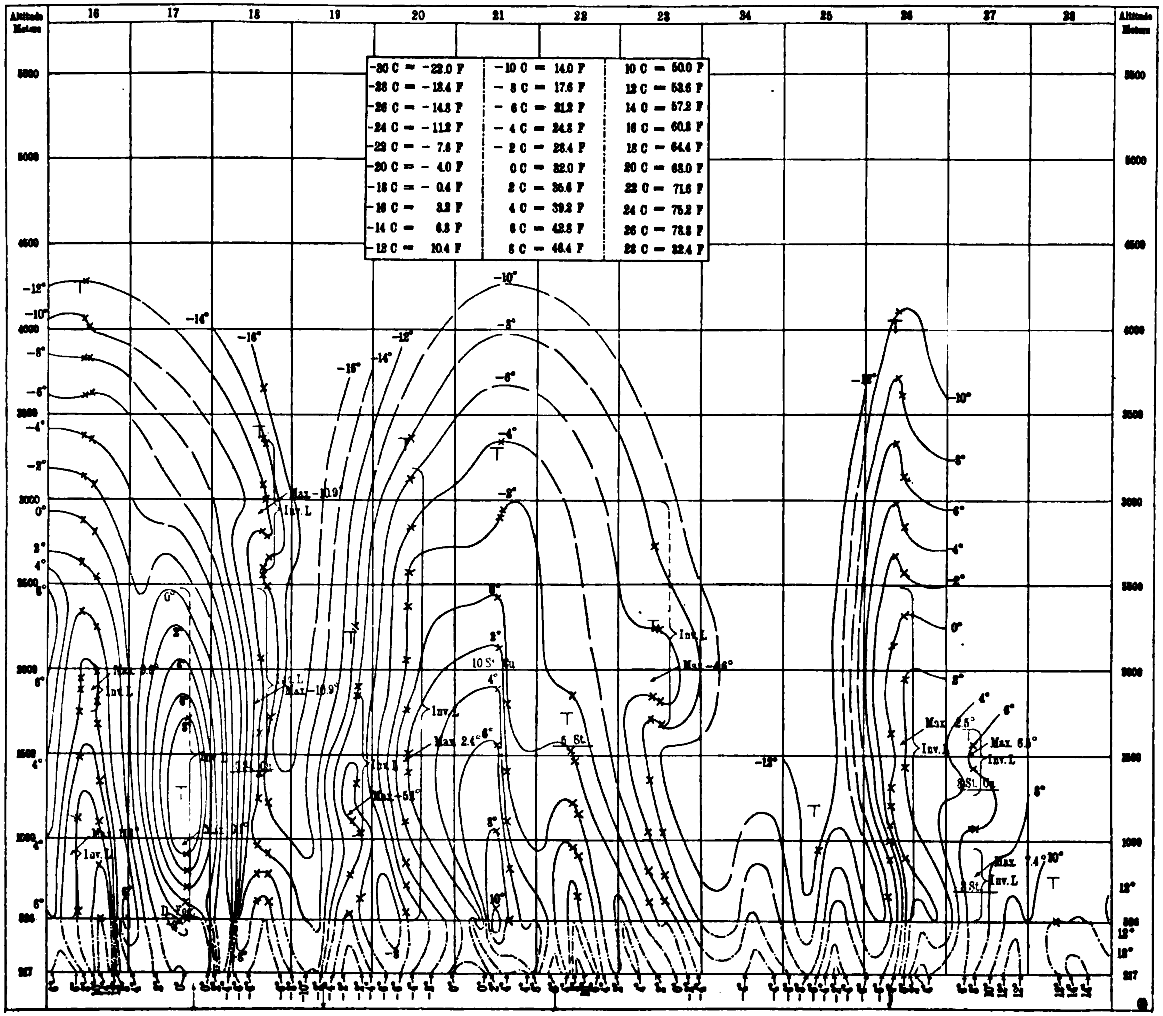
Free air isotherms, January 1–15, 1910.



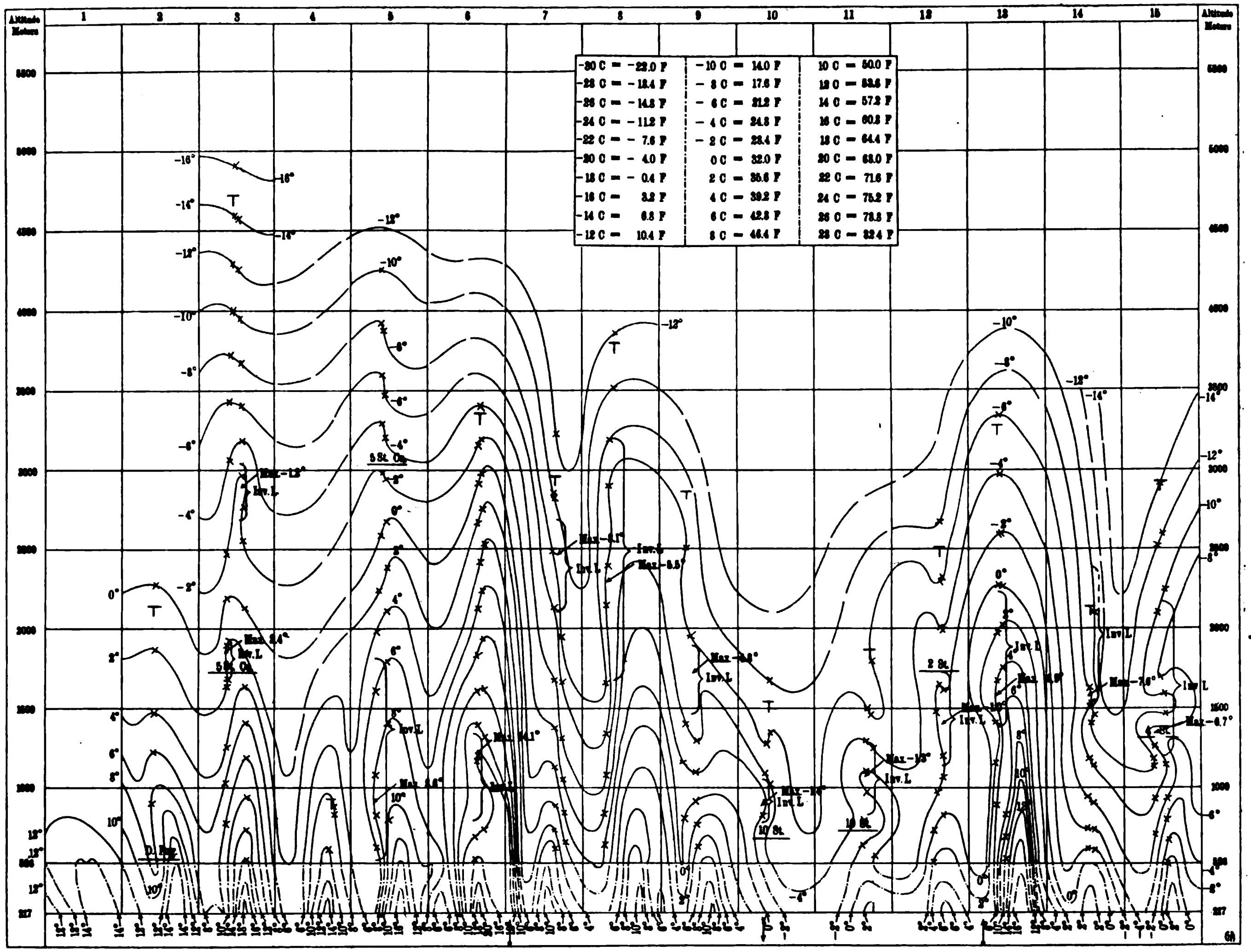
Free air isotherms, January 16–31, 1910.



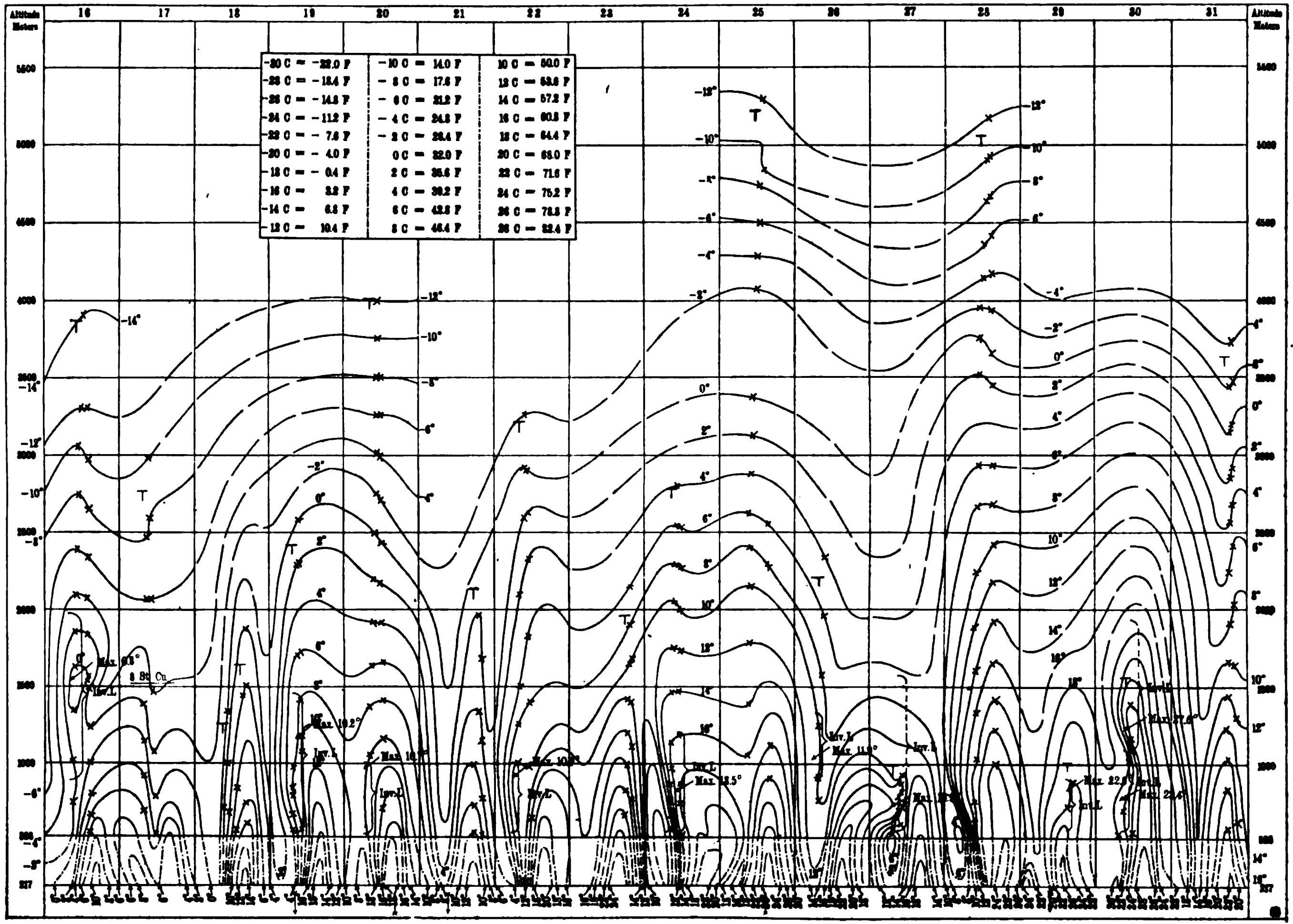
Free air isotherms, February 1-15, 1910.



Free air isotherms, February 16–28, 1910.



Free air isotherms, March 1-15, 1910.



Free air isotherms, March 16–31, 1910.

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BULLETIN
OF THE
MOUNT WEATHER OBSERVATORY.

Vol. 3. Part 2. | Extra Number. CLEVELAND ABBE, Editor. | Closed June 30, 1910 Issued Oct. 5, 1910

(III) SOLAR RADIATION, ATMOSPHERIC ABSORPTION, AND SKY POLARIZATION, AT WASHINGTON, D. C.

By HERBERT H. KIMBALL. (Dated June 12, 1910.)

INTRODUCTION.

Solar radiation observations may conveniently be subdivided into five classes as follows:

(1) *Determination of the relative intensity of the radiant energy received at any time from different points on the sun's disk, as from a sun spot or from an unspotted area, or from points near the center or near the edge of the disk.* These latter have to do with the absorption of energy in the sun's own atmosphere. The most complete series of observations of this class has been obtained spectrobolometrically, at the Astrophysical Observatory of the Smithsonian Institution. Published bolographs[1] show that sun spots are cooler than the regions surrounding them, and also that radiation of short wave lengths is more absorbed in the sun's atmosphere than is radiation of longer wave lengths.

Evidence has also been obtained of variations in the transmission coefficient of the solar atmosphere,[2] variations which would account for changes in the value of the so-called solar constant.

(2) *Determinations of the intensity of the radiant energy received from the sun at a given time at the outer limit of the earth's atmosphere.* When expressed in gram-calories per minute per square centimeter of normal surface, and reduced to mean distance of the earth from the sun, the term *solar constant* is usually applied to this intensity. For its determination, in addition to accurate measurements of the intensity of the radiation re-

[1] Annals of the Astrophysical Observatory of the Smithsonian Institution, Vol. 2, plate 28, and p. 233; Annual Report of the Smithsonian Institution, 1904, Plate 8. See also Millochau, Recherches sur la temperature effective du soleil. Journal de Physique, Tome 6, p. 389, 1907.

[2] Annals of the Astrophysical Observatory of the Smithsonian Institution, Vol. 2, p. 232; Astrophysical Journal, Vol. 29, p. 281.

ceived at the place of observation, it is necessary to ascertain what proportion of the energy of different wave lengths has been absorbed in the layer of the earth's atmosphere lying between the place of observation and the sun. This, too, has been best accomplished, spectrobolometrically, at the Astrophysical Observatory of the Smithsonian Institution.[3]

(3) *Determinations, in absolute units, of the intensity of the radiant energy received from the sun at a given place and time.* These include all those numerous measurements made at a great number of observatories throughout the world, whether with instruments whose constants have been accurately determined and whose indications may therefore at once be expressed in absolute units, or with those whose readings can best be reduced to absolute measures through comparison with some standard instrument.

(4) *Determinations of the amount of radiant energy received from the sun on a normal surface at a given place during a definite period of time—a day, a month, or a year—expressed in either absolute or relative units.* These require the employment of continuously registering apparatus, such as Crova's[4] recording actinometer, Ångström's[5] recording pyrheliometer, or Abbot's[6] standard pyrheliometer.

(5) *Determinations of the amount of radiant energy, expressed in either absolute or relative units, that is received on a horizontal surface from the entire hemispherical vault of the sky, including that portion occupied by the sun.* The measurement of this quantity of energy, which is of paramount interest to the climatologist and agriculturist, also requires a recording apparatus, as, for example, Callendar's horizontal bolometer.[7]

DATA EMPLOYED IN THIS RESEARCH.

The present research is confined principally to a discussion of observations of the third class, obtained by the author at Washington, D. C., between May 1, 1905, and April 30, 1910. This is preceded by a study of the principal instruments now employed in observational work of this character, together with a summary of comparisons between instruments of different types obtained by the writer and others. It is followed by a discussion of a method first proposed by Ångström[8] for the computation

[3] Annals of the Astrophysical Observatory of the Smithsonian Institution, Vol. 2.

[4] Sur l'enregistrement de l'intensité calorifique de la radiation solaire: par M. A. Crova. Annales de Chimie et de Physique, Series 6. Tome 14, p. 121; Comptes Rendus, Tome 125, p. 804.

[5] Nova Acta Reg. Soc. Scient. Upsal. Ser. III, 1887, p. 1–17.

[6] Annals of the Astrophysical Observatory of the Smithsonian Institution, Vol. 2, p. 39; Astrophysical Journal, Vol. 29, p. 281.

[7] Proc. Royal Soc. 1906, Ser. A. Vol. 77, p. 15.

[8] Nova Acta Reg. Soc. Scient. Upsal. Ser. IV. Vol. 1, No. 7.

of the solar constant, which is based on the mean results of spectrobolometric work on atmospheric absorption.

In computations by this method it is necessary to assume that the atmospheric transmissibility was constant for a considerable time, which in this investigation has been that occupied by the sun in passing from zenith distance 60° to zenith distance 71°, or during a period varying in length from one hour in summer to two hours in winter. Atmospheric conditions, especially near sea level, are continually undergoing changes, which affect the transmissibility, sometimes markedly, at others only slightly. It has been found that a change in the atmospheric transmissibility, except when due to aqueous vapor absorption, is accompanied by a change in the polarization of sky light. The percentage of this polarization at its maximum point has therefore been measured whenever pyrheliometric readings were obtained, and the data have been utilized in connection with computations of the value of the solar constant.

A short series of records of the fifth class, obtained by the Instrument Division of the Weather Bureau, has been utilized in computing the total radiation received on a horizontal surface at Washington on certain typical days, and also during the months of August, September, and October, 1909.

Pyrheliometer observations were first undertaken by the author at Asheville, N. C.,[9] in November, 1902. In April, 1903, the work was transferred to Washington. At first, observations were made every hour or half hour during the day, without much regard to sky conditions, but since April, 1903, they have been confined to days when the sky was practically free from clouds. The present system of distributing the observations according to the length of the path of the sun's rays through the earth's atmosphere, which is usually called the air mass, was not adopted until May, 1905. Polarimeter observations were commenced at Asheville, N. C., in December, 1902, and at Washington in May, 1903.

From May to November, 1905, the observations were made at the Astrophysical Observatory of the Smithsonian Institution, where there was somewhat more smoke in the atmosphere than is the case at the Weather Bureau.

At the latter point the observations have been made on the roof of the main building, 118 feet above sea level. Since December, 1906, the pyrheliometer has been exposed in a specially constructed shelter, with sliding shutters in the south side of its roof, so that the apparatus is

[9] Monthly Weather Review, 1903, Vol. 31, p. 320.

well protected from air currents, which had previously been a source of annoyance.

There have been utilized in this research more than 7,350 separate determinations of the intensity of solar radiation, obtained between May 1, 1905, and April 30, 1910. These are distributed over 272 half-day periods, on 199 of which the variations in the length of the air mass exceeded one unit, that is, the zenith depth of the earth's atmosphere. Each separate determination has been derived from the mean of two pyrheliometric readings, with each of the two pyrheliometric strips alternately exposed to and protected from solar radiation. On an average, therefore, 54 readings of the pyrheliometer have been made during each half-day period. When the sky was unusually clear, however, the number of readings has often been more than double this number. In addition, there have been utilized observations made between 9 a. m. and 4 p. m. on 124 days during the months of April to December, inclusive, in 1903 and 1904. These have sufficed to determine the intensity of solar radiation when the sun was on the meridian.

The measurements of the polarization of skylight have not averaged more than six to eight in each half-day period.

INSTRUMENTS.

Actinometers and pyrheliometers.—The name *pyrheliometer* was given by Pouillet[10] to an instrument designed by him for directly measuring the increase in temperature of a known volume of water contained in a blackened silver vessel when exposed to solar radiation. The principle embodied in this instrument is still extensively employed in the construction of pyrheliometers, though mercury has generally been substituted for water to fill the vessel.

Sir John Herschel[11] gave the name *actinometer* to an instrument devised by himself, which was similar to Pouillet's pyrheliometer, except that the bulb was of glass, unblackened, and filled with a dark blue liquid. For "the absolute unit of solar radiation to be adopted in the ultimate reduction of the actinometer observations," Herschel proposed the name *actine* or "that intensity of solar radiation which at a vertical incidence, and supposing it wholly absorbed, would suffice to melt one-millionth part of a meter in thickness from the surface of a sheet of ice horizontally exposed to its action per minute of mean solar time." No well-defined distinction appears to have been made between the use of the terms actinometer and pyrheliometer as applied to instru-

[10] Comptes Rendus, 1838, Tome 7, p. 24.

[11] The Admiralty Manual of Scientific Enquiry, London, 1849, p. 287.

ments for measuring the intensity of solar radiation until Crova[12] proposed to designate as pyrheliometers all those instruments whose constants can be accurately determined, and whose indications can at once be reduced to absolute units, while to those instruments whose constants can not be accurately determined, and whose indications can best be reduced to absolute units by comparison with the indications of some standard instrument, he proposed to give the name *actinometer*. This distinction appears subsequently to have been followed by most of the leading investigators in this branch of meteorological science; but since the *actine* is no longer employed as a unit in measuring the heating effect of absorbed solar radiation, there would appear to be no reason for designating as actinometers any of the various instruments that measure the intensity of solar radiation through the change in temperature produced in a body by exposing it to the radiation. The term actinometer will not, therefore, be used in this paper, except when referring to instruments which have been so designated by their makers.

METHODS OF OBSERVATION.

The earlier instruments were of a form adapted to determining the rate of change of temperature in a body exposed to radiation. Two observational methods were developed, known as *static* and *dynamic*.

(1) In the static method we determine the maximum excess of temperature over that of the surrounding medium that can be attained by a body exposed to solar radiation. Should this maximum excess actually be attained there will be equilibrium of temperature, in that the rate at which heat is being received will just equal the rate at which it is being lost. But on account of the uncertainties attending the measurement of the maximum excess of temperature attained by a body exposed to radiation, the static method has generally given place to the dynamic method.

(2) In the dynamic method it is necessary to determine the *rate* at which a body exposed to radiation gains in heat, and also the rate at which it loses heat under similar conditions except that it is in the shade. If we measure directly the rate of gain in heat, the rate of loss of heat must be determined indirectly.

FUNDAMENTAL EQUATIONS.

The fundamental pyrheliometric equations for both the static and the dynamic methods are similar in form. They have been very fully developed by Chwolson[13] by first making certain approximately correct as-

[12] Annales de Chimie et de Physique, 1877, Ser. 5, Tome 11, p. 467.

[13] Wild's Repertorium für Meteorologie, Band 16, No. 5.

sumptions, and then later discussing the effect of deviations from the supposed conditions. The assumptions are as follows:

1. The radiation to be measured remains constant in intensity and character during the period occupied by a single determination.

2. The absorbing power of the surface receiving the radiation is constant, and in the preliminary investigation will be assumed to be unity.

3. At any given instant all parts of the body, whether exposed to radiation or in the shade, have the same temperature.

4. The loss of heat from the body, both when exposed to radiation and when in the shade, follows the Newtonian law; that is to say, it is proportional to the excess of temperature of the body over that of the surrounding medium.

5. The coefficient of cooling remains constant, at least during the time required for a single measurement.

Let S represent the entire surface of the body receiving the radiation, s the cross sectional area of the bundle of solar rays falling normally upon its front surface, c the water equivalent of the body, h the coefficient of heat loss by conduction, T its excess of temperature over that of the surrounding medium, and t the time.

Further, let the unit surface be the square centimeter, and the unit of time the minute.

The variable thermometric state of a pyrheliometric body may be expressed by the equation

$$cdT = qsdt - hSTdt \tag{1}$$

where q is the intensity of the solar radiation received.

If the body is in the shade $q=0$ and (1) becomes

$$\frac{dT}{T} = -\frac{hS}{c}dt \tag{2}$$

Integrating (2) we obtain

$$\log T = -\frac{hS}{c}t + \text{constant.} \tag{3}$$

Let T_0 be the temperature corresponding to $t=0$. Then

$$T = T_0 e^{-\frac{hS}{c}t}. \tag{4}$$

$$\text{Let } m = \frac{hS}{c}\text{; then} \tag{5}$$

$$T = T_0 e^{-mt} \tag{6}$$

Let T_1 be the maximum value of T, or its value when stationary temperature conditions have been reached with exposure to solar radiation, and in consequence $dT=0$.

From (1)

$$T_1 = \frac{qs}{Sh}. \tag{7}$$

Multiplying together equations (5) and (7), we obtain

$$mT_1 = \frac{qs}{c}. \tag{8}$$

Equation (7) has little significance in itself, since with a considerable increase in T the value of h also increases. Equation (8) on the other hand has a real physical significance, since it indicates the rise in temperature that would occur in a unit of time in a body exposed to solar radiation, provided that no heat is lost by radiation, that only the amount qs is absorbed, and that, in accordance with the fifth assumption, the value of m, the coefficient of cooling, remains constant during the period of observation. In general, this can not be the case unless the change in the value of T during the time required to make the determination is small.

From (8) we obtain at once

$$q = \frac{c}{s} mT_1 = kmT_1 \tag{9}$$

where $k = \frac{c}{s}$ is a constant that may be determined once for all for any given instrument.

Dividing equation (1) by c we obtain

$$dT = mT_1 dt - mTdt, \text{ or} \tag{10}$$

$$\frac{dT}{T_1 - T} = mdt. \tag{11}$$

Integrating (11), and again taking $T_0 = T$ when $t=0$, we obtain

$$\log \frac{T_1 - T_0}{T_1 - T} = mt, \text{ or } \frac{T_1 - T_0}{T_1 - T} = e^{mt} \tag{12}$$

$$\text{and } T = T_0 e^{-mt} + T_1(1 - e^{-mt}) \tag{13}$$

Equation (13) gives the variable temperature of a body exposed to radiation, while equation (6) gives the temperature of the same body in the shade.

ÅNGSTRÖM'S METHOD.

Ångström[14] first proposed to alternate two similar pyrheliometric bodies between exposure to and protection from solar radiation. This so complicates the apparatus that it is necessary to add the following assumptions:

6. The two pyrheliometric bodies are duplicates to the extent that they have the same geometric dimensions, the same water equivalents, and, at all times, the same coefficients of cooling and absorption.

7. Aside from solar radiation directly received, the two pyrheliometric bodies are not unequally affected by any source of heating or cooling.

Chwolson's[15] development of the equations for an actinometer constructed by himself embodying the principles of Ångström are slightly modified in the following equations.

Let T_a represent the excess of temperature of the body in the shade over that of the surrounding medium, T_e the corresponding excess of the body exposed to radiation, and θ their difference of temperature. Further let the initial difference of temperature be represented by $\theta_0 = T_{e,0} - T_{a,0}$.

The excess of temperature of the two bodies expressed as a function of time is derived from equations (6) and (13), as follows:

$$T_a = T_{a,0}e^{-mt} \text{ and} \tag{14}$$

$$T_e = T_{e,0}e^{-mt} + T_1(1 - e^{-mt}). \tag{15}$$

Subtracting (14) from (15)

$$\theta = T_e - T_a = \theta_0 e^{-mt} + T_1(1 - e^{-mt}) \tag{16}$$

from which

$$T_1 = \frac{\theta - \theta_0 e^{-mt}}{1 - e^{-mt}} \text{ and } q = kmT_1 = k\frac{m}{1 - e^{-mt}}(\theta - \theta_0 e^{-mt}). \tag{17}$$

When $t = \infty$ we obtain from (16) $\theta = T_1$; from (15) $T_e = T_1$; and consequently from (16) $T_a = 0$. Apparatus embodying the Ångström principle may therefore be employed in static observations, if the pyrheliometric bodies are sufficiently sensitive so that the condition $\theta = T_e = T_1$ is quickly attained. In other forms of pyrheliometric apparatus employed in statical measurements it is necessary to provide some means of determining accurately the temperature of the surrounding

[14] Nova Acta Reg. Soc. Scient. Upsal. Ser. III, 1887, p. 1–17.

[15] Loc. cit.

medium as well as that of the pyrheliometric body. Violle's[16] actinometer, both in its original form and also as modified by Savelief,[17] is a well known instrument adapted to measurements of this kind.

THE DYNAMIC METHOD.

The apparatus employed in static measurements may also be employed in dynamic measurements. Thus, slightly modifying Chwolson's equations so as to conform to the notation here adopted, if we represent by θ_0, θ_1, and θ_2 the temperature differences of the two pyrheliometric bodies in the Ångström–Chwolson pyrheliometers after the time intervals $t=0$, $t=1$, and $t=2$, respectively, then from equation (16)

$$\theta_1=\theta_0 e^{-mt}+T_1(1-e^{-mt}), \text{ and} \tag{18}$$

$$\theta_2=\theta_1 e^{-mt}+T_1(1-e^{-mt}), \tag{19}$$

from which by subtraction

$$e^{mt}=\frac{\theta_0-\theta_1}{\theta_1-\theta_2}, \text{ and } m=\frac{1}{t}\log\frac{\theta_0-\theta_1}{\theta_1-\theta_2}; \tag{20}$$

also from (18)

$$T_1-T_1 e^{-mt}=\theta_1-\theta_0 e^{-mt}. \tag{21}$$

Substituting for e^{-mt} in (21) its value from (20) we obtain

$$T_1=\frac{\theta_0\theta_2-\theta_1^2}{\theta_0-2\theta_1+\theta_2} \tag{22}$$

Substituting (20) and (22) in (9) we obtain

$$q=\frac{c}{s}mT_1=\frac{c}{s}\frac{1}{t}\frac{\theta_0\theta_2-\theta_1^2}{\theta_0-2\theta_1+\theta_2}\log\frac{\theta_0-\theta_1}{\theta_1-\theta_2} \tag{23}$$

which simplifies to the approximate form

$$q=\frac{2c}{s}\frac{1}{t}\frac{\theta_0\theta_2-\theta_1^2}{\theta_0-2\theta_1+\theta_2}\left(1+\frac{1}{12}m^2t^2\right) \tag{24}$$

and again to

$$q=\frac{2c}{s}\frac{1}{t}\frac{\theta_0\theta_2+\theta_1^2}{\theta_0+\theta_2}=k\frac{2}{t}\frac{\theta_0\theta_2+\theta_1^2}{\theta_0+\theta_2} \tag{25}$$

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[16] Mémoire sur le temperature moyenne de la surface du soleil. Annales de Chimie et de Physique, 1877, Tome 10, p. 289; Rapport sur la question 19 du programme pour le Congrés Météorologique de Rome. Premiér partie. Annales de Chimie et de Physique, 1879, Tome 17, p. 391.

[17] Sur le degré de precision que l'on peut attendre dans les observations actinometriques. Annales de Chimie et de Physique, 1893, Tome 28, p. 394.

DESAINS' PRINCIPLE.

Smirnow[18] employed the principle of Desains[19] in the discussion of the adaptation of the Violle–Savelief actinometer to dynamic processes. Representing by T_a, T_e, and T_m the temperatures of the body in the shade, of the body in the sun, and of the surrounding medium, respectively, the principle of Desains simply means that for a given value of q the sum of the rate of warming and the rate of cooling is a constant, provided these rates are obtained when $T_e = T_a$, and T_m has remained constant.

Substituting T_a, T_e, and T_m in equations (1) and (2) we obtain

$$qsdt = cdT_e + hS(T_e - T_m)dt \tag{26}$$

$$0 = cdT_a + hS(T_a - T_m)dt \tag{27}$$

Let t_0 = time when $T_a = T_e$; then at this time we have, if T_m is constant,

$$hS(T_e - T_m)dt_0 = hS(T_a - T_m)dt_0 = -cdT_a, \tag{28}$$

or

$$qsdt_0 = c[dT_e - dT_a]_{T_e = T_a} \tag{29}$$

Since the sign of dT_a is in general opposite to the sign of dT_e, the expression in brackets in equation (29) represents the arithmetical sum of the rates of warming and cooling, when $T_e = T_a$ and T_m has remained constant. Equation (29) may therefore be conveniently written

$$q = \frac{c}{s}\left[\frac{dT_e}{dt_0} - \frac{dT_a}{dt_0}\right]_{T_e = T_a} = k(V + U) \tag{30}$$

Smirnow computed the value of q from a series of observations of the values of T_a, T_e, and T_m by means of the three following formulas, with the results indicated:

I. From equation (17)

$$q = k\frac{m}{1 - e^{-mt}}(\theta - \theta_0 e^{-mt}) = 1.637\ k.$$

Here $e^{-mt} = \frac{T_a}{T_{a,0}}$, from equation (14).

II. From equation (25)

$$q = k\frac{2}{t}\frac{\theta_0\theta_2 + \theta_1^2}{\theta_0 + \theta_2} = 1.634\ k.$$

III. From equation (30)

$$q = k(V + U) = 1.652\ k.$$

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[18] Met. Zeit. 1908, Band 25, p. 299.

[19] Comptes Rendus, 1874, Tome 78, p. 1455.

To obtain this latter result V is directly observed; U is the mean of the rates of cooling immediately before and immediately after V was observed, corrected by the amount $\Delta U = \frac{hS}{c} \Delta T_a = m\Delta T_a$, where $\Delta T_a = T_e - T_a$. This correction is made necessary by the fact that it is impracticable to obtain $\frac{dT_e}{dt}$ and $\frac{dT_a}{dt}$ at the exact moment when $T_e = T_a$. In the above example $\Delta T_a = -0.06°$ Centigrade, and $m = 0.2$; the correction was therefore $+0.012°$.

On the other hand if the rates of warming and cooling are obtained, not at the time $t = t_0$, but during an interval both preceding and following t_0, then equation (30) may be expressed in the form

$$\frac{dT_e}{dt} - \frac{dT_a}{dt} = \frac{qs}{c} e^{-mt} \tag{31}$$

and

$$\frac{1}{2}\int_{+1}^{-1} \frac{qs}{c} e^{-mt}\, dt = \frac{qs}{c}\left(1 + \frac{1}{6} m^2\right) \tag{32}$$

From a comparison of equations (8) and (32) it is seen that the result in III from equation (30) should be about 0.7 per cent higher than the results in I and II from equations (17 and (25).

It will be noted that equations (17) and (25) were developed with special reference to their application to observations with the Ångström–Chwolson pyrheliometer, but that they appear to be equally applicable to observations with the Violle–Savelief instrument. Furthermore, since they have to do with the difference in temperature of bodies exposed to and protected from radiation, they are equally applicable to observations with pyrheliometers of the Pouillet type, provided only that the temperature of the surrounding medium is constant, or at least changes at a uniform rate.

The discussions of Chwolson, Gorczynski, Smirnow, and others, which relate principally to errors peculiar to special instruments, will not here be considered in full, but only such conclusions as are general in their character.

ÅNGSTRÖM'S ELECTRICAL COMPENSATION PYRHELIOMTEER.

It may be stated that Ångström[30] attempted to avoid many of these errors in the construction of his electrical compensation pyrheliometer, which makes use of the static method of observation, in that the heating

[30] Astrophysical Journal, Vol. 9, p. 332.

effect of the solar radiation on a thin strip of blackened manganin is balanced against the heating effect of an electric current in passing through a similar strip in the shade. The supposition is that since the two strips are maintained at the same temperature and under precisely similar conditions the strength of current required to maintain this temperature, T_1, in the shaded body, will be a measure of the rate at which radiation is being received on the exposed body. And since the constants of the instrument, that is to say, the width b of the strips, their electrical resistance per unit of length, r, and the coefficient of absorption of the exposed surfaces, a, are originally easily determined, it has been assumed that the indications of the instrument may be directly reduced to absolute heat units by the equation

$$q = K\frac{ri^2}{ba} = K'i^2$$

where i is the strength of the current flowing through the shaded strip, and K is a constant depending upon the relation between thermal and electrical units.

Two possible sources of error in these determinations are to be considered:

1st. Ångström gives the value of a as 0.98, and Crova[21] has shown that this coefficient may be relied upon for freshly blackened surfaces suitably prepared. With use, however, the surface collects dust, and in some cases the soot flakes off, so that a considerable change may occur in the absorbing power of the blackened surfaces. Unfortunately, these surfaces in the Ångström compensation pyrheliometer are not easily renewed.

2d. Gorczynski[22] has shown that in pyrheliometric bodies consisting of a glass case blackened on the outside and filled with mercury, or, indeed, with any other substance, if we consider two such bodies, one exposed to radiation and the other protected from it, whose indicated temperatures T_e and T_a are equal, it is evident that on account of imperfect heat conduction through the glass envelope and its outer coating of black, the surface of the body receiving radiation will be warmer than the surface of the body that is cooling. For this reason equation (25) is modified as follows:

$$q = k'\frac{2}{t}\cdot\frac{\theta_0\theta_2+\theta_1^2}{\theta_0+\theta_2} \tag{33}$$

[21] Sur le pouvoir absorbant du noir de fumée pour la chaleur rayonnante. Note de MM. Crova et Compan. Comptes Rendus, 1898, Tome 126, p. 707.

[22] Sur la marche annuelle de l'intensité du rayonnement solaire à Varsovie, et sur la theorie des appareils employés Varsovie, 1906.

in which $$k' = \frac{c}{s}(1 + h\frac{d}{k})$$

where h has the same significance as heretofore, d is the thickness of the glass envelope, and k its coefficient of heat conductivity. It therefore appears that the greater the value of d and the smaller the value of k the greater is the required correction.

While the Ångström instrument[23] has no glass case, there must be a temperature gradient from the blackened front of the manganin strip receiving radiation to the back of the copper strip to which the thermal element is attached; and it may well be that this gradient is different in the strip warmed by radiation from what it is in the shaded strip that is warmed by the passage through it of an electric current, although Kurlbaum[24] has shown that the difference will be slight.

THE MARVIN PYRHELIOMETER.

Marvin, employing the principle of the electrical resistance thermometer, has constructed a pyrheliometer by imbedding in a silver block the wire whose resistance indicates the temperature. Here also there is a temperature gradient from the blackened surface to the wires in the center of the block, the character of which can be studied in detail in this form of apparatus. However, after the first ten seconds of exposure or shading a steady flow of heat through the block is established, which nullifies the effect of the gradient. In an improved form of this pyrheliometer a thin insulated nickel or copper ribbon is wound into a compact spool, and one of the flat surfaces is carefully smoothed and blackened to receive the radiation. Any heat absorbed will at once show itself by a change in the electrical conductivity of the ribbon—a change, too, that depends solely upon the quantity of heat absorbed, and not at all upon its distribution.

The heating effect is determined from the readings of a box bridge and the deflections of a galvanometer, and on account of the open scale of the latter in comparison with that of a mercurial thermometer, greater accuracy is obtained in two ways; 1st by reducing the probable error of the readings themselves, and 2d, by decreasing the reading time—an important consideration, as shown in the discussion of equation (8).

COMPARISON OF PYRHELIOMETERS.

In all these various instruments, except the Ångström electrical compensation pyrheliometer, the accuracy of the result depends not only

[23] For details of construction see Ångström's original paper already referred to.

[24] Annalen der Physik und Chemie, 1899, Band 67, p. 846.

upon the accuracy of the determination of the instrumental constants, but also upon the accuracy with which the rates of heating and cooling, $\frac{dT_e}{dt_0}$ and $\frac{dT_a}{dt_0}$ are determined. Only one of these rates can be directly measured, and the accuracy of the determination of the other depends upon the accuracy of our knowledge of the laws of cooling, which are only approximately expressed by equation (6). This subject is now being investigated by Professor Marvin.

Since, as has been shown, the same theoretical equations apply to pyrheliometers of such different types as the Violle–Savelief, the Ångström–Chwolson, and various modifications of the Pouillet instrument, we would expect their readings to be quite closely in accord when reduced to absolute heat units, and also to agree with the indications of Ångström's electrical compensation and Abbot's absolute pyrheliometers. This agreement, however, has not yet been fully realized. And as the International Union for Cooperation in Solar Research[25] has recommended that the Ångström pyrheliometer be adopted as the standard instrument, it becomes desirable to compare the indications of other pyrheliometers with the Ångström whenever this is possible.

First, however, reference should be made to the fact that the indications of Ångström instruments are not always in accord among themselves.[26]

Comparisons of nine different instruments at the Weather Bureau indicate that eight of these were in practical accord when received from the maker, the discrepancies between them not amounting to more than 1 per cent. After continued use, however, sometimes for a period of two or three years, the coefficient of absorption, a, apparently becomes smaller, so that the indications of the instrument may be as much as 11 per cent too low. Ångström has recognized this tendency, and has recommended the maintenance of a standard instrument at each central observatory, and its return from time to time to Upsala for comparison with the primary standard.[27] The U. S. Weather Bureau maintains Ångström pyrheliometer No. 104, received in December, 1907, as such a standard. In addition, through the courtesy of the Director of the Astrophysical Observatory of the Smithsonian Institu-

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[25] Transactions of the International Union for Cooperation in Solar Research, Vol. 1, p. 239.

[26] See Bulletin of the Mount Weather Observatory, Vol. 1, p. 83; Met. Zeit, 1908, Vol. 25, p. 299.

[27] Report of the International Metorological Committee, Paris, 1907, p. 61.

tion, it has made frequent comparisons between the pyrheliometers employed at that observatory and Ångström instruments. These, as well as comparisons with Ångström No. 122, received in October, 1909, indicate that the standard instrument, No. 104, has undergone practically no change since it has been in the hands of the Weather Bureau.

The behavior of other Ångström instruments which have been used in regular observational work is shown by the ratios in Table 1.

Until recently, as above implied, there appear to have been considerable discrepancies between the indications of pyrheliometers of different types, but these differences are gradually being reduced.

Thus, in an earlier paper[28] the author has shown that the Smithsonian standard pyrheliometer read about 11 per cent higher than the Ångström standard. Recent redeterminations of the constants of the Smith-

TABLE 1.—*Comparisons of Ångström pyrheliometers. Ratios of the results given by different instruments.*

Date	No. of readings.	No. 31 / No. 34	No. 28 / No. 34	No. 41 / No. 34	No. 90 / No. 28bis	No. 31 / No. 28bis	No. 104 / No. 28bis	No. 105 / No. 28bis	No. 105 / No. 104	No. 105 / No. 31
October 25, 1901	11	1.005								
October 29, 1901	20		0.917							
April 9, 1903	4		0.936							
June 16, 1903	2			1.003						
June 18, 1903	4			1.010						
April 15, 1905	4			0.977						
April 25, 1905	6			0.960						
April 28, 1905	2			0.958						
December 22, 1905	4			0.958						
December 26, 1905	10			0.947						
January 9, 1906	12			0.988						
January 10, 1906	10			0.985						
January 29, 1906	4	0.924								
Do	2			0.958						
January 30, 1906	2			0.968						
February 6, 1906	2			0.904						
February 14, 1906	2			0.931						
July 27, 1907	14				0.982					
December 5, 1907	14					0.955				
December 6, 1907	12					0.961				
December 31, 1907	4						1.057			
Do	4								1.014	
January 2, 1908	2							1.028		
January 3, 1908	5							1.097		
Do	2									1.060
January 6, 1908	4									1.076
January 9, 1908	4									1.075
Do	8							1.065		
January 14, 1908	12							1.070		
January 15, 1908	2							1.072		
January 17, 1908	6							1.067		
Do	4									1.096
January 30, 1908	2									1.100
Do	10								1.008	
Do	4							1.066		

[28] Bulletin of the Mount Weather Observatory, Vol. 1, p. 83.

TABLE 1.—*Comparisons of Angström pyrheliometers. Ratios of the results given by different instruments*—Continued.

Date	No. of readings.	No. 31 / No. 28_{bis}	No. 104 / No. 28_{bis}	No. 105 / No. 31	No. 105 / No. 28_{bis}	No. 105 / No. 90	No. 122 / No. 28_{bis}	No. 122 / No. 104	No. 122 / No. 105
February 6, 1908	8					1.061			
February 7, 1908	2		1.061						
February 8, 1908	6		1.065						
Do	8					1.064			
April 4, 1908	2	1.029							
April 11, 1908	2	1.024							
April 13, 1908	4		1.072						
April 16, 1908	2	1.017							
April 21, 1908	2	1.034							
May 26, 1908	2	1.021							
June 1, 1908	2		1.070						
June 2, 1908	12	1.023							
July 11, 1908	2			1.003					
July 16, 1908				1.011					
September 8, 1908	2		1.083						
September 16, 1908	4		1.076						
September 29, 1908	2		1.088						
November 12, 1908	2		1.079						
November 13, 1908	6				1.052				
March 23, 1909	4		1.102						
April 24, 1909	4		1.092						
August 2, 1909					1.056				
August 9, 1909					1.034				
August 30, 1909					1.064				
September 25, 1909	8		1.113						
October 19, 1909	6						1.104		
October 22, 1909	4						1.095		
Do	10							1.005	
October 25, 1909	8						1.110		
November 13, 1909	2								1.044
January 13, 1910	4								1.023
February 25, 1910	4		1.110						
March 21, 1910	8		1.106						

sonian absolute instrument have reduced this difference to 5.4 per cent.[29] Smirnow[30] refers to many comparisons executed by himself and others between Ångström compensation pyrheliometers, an Ångström differential pyrheliometer, a Violle-Savelief actinometer, and a Chwolson actinometer. Unfortunately, the Ångström compensation pyrheliometers employed differed among themselves by nearly 4 per cent. In general, however, the Ångström differential pyrheliometer read higher, and the Violle-Savelief and the Chwolson actinometers read lower than the Ångström compensation pyrheliometer by amounts ranging from zero to 6 per cent, depending upon what particular instrument of each kind was employed in the comparison.

[29] *The above percentage is based on information furnished by the Smithsonian Institution since this paper was sent to the printer. In the meantime Professor Marvin had determined the constants to his nickel spiral pyrheliometer, with the exception of the coefficient of absorption of the blackened surface. Assuming this to be 0.983, careful comparisons made by the author between the Marvin instrument and a new Abbot silver disk pyrheliometer show that the former is in accord with the Smithsonian absolute pyrheliometer. This makes it highly probable that the Ångström pyrheliometric scale, which has been adopted in this paper, gives results that are about 5 per cent too low.*

[30] Met. Zeit. Band 25, p. 299.

Evidently there is need of an international standard of pyrheliometry, as has been suggested by Ångström.

OBSERVATIONS OF THE INTENSITY OF SOLAR RADIATION AT WASHINGTON, D. C.

A single observation with a pyrheliometer whose constants are known measures the rate at which solar radiation is being received at the time and place of observation under the atmospheric conditions then prevailing. But since this rate undergoes constant change, not only with time but also with meteorological conditions, it is necessary to obtain a great many observations in order to determine the maximum or the mean rate for any specified season of the year at a given place. Furthermore, there is also a variation in rate with geographical position. A great many observations at many different observatories will therefore be necessary for a complete study of the rate at which solar radiation is received at all points on the globe. In 1905 Rizzo[31] gave a list of 23 places at which pyrheliometric observations were then being made. Published data is not, however, available from all of these. There is also a lack of uniformity in the methods of tabulating the data, which renders comparisons difficult. Above all, in many cases there is no means of determining how nearly the pyrheliometric standards employed at different stations are in accord.

The observations presented in Table 2 have been reduced to the scale of Ångström pyrheliometer No. 104, whose constants are believed to have remained unchanged since they were determined by Ångström in 1907. (See footnote No. 29). The reduction has been effected by means of the ratios in Table 1, supplemented by comparisons with the Smithsonian standard. In fact, the reduction factors employed prior to December, 1907, have been obtained almost entirely through comparisons between Ångström and Smithsonian instruments, the results of which have already been published in the Bulletin of the Mount Weather Observatory, Vol. 1, p. 92. The history of the different Ångström instruments with which observations have been obtained is also given in this Bulletin, Vol. I, p. 86. Pyrheliometer No. 28_{bis} is still in use at Washington. Since there is some doubt as to the value of the reduction factors previous to May, 1905, and, moreover, since the system of observing was changed in that month, observations obtained prior to that date are not included in Table 2.

[31] South Kensington, Solar Physics Observatory. Report made to the Solar Physics Committee by Sir Norman Lockyer, 1905, p. 21.

TABLE 2.—*Washington pyrheliometer readings reduced to the scale of Angström No. 104, and expressed in gram-calories per minute per square centimeter of normal surface.*

Date.	Air mass.								
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
January 28, 1907, a. m.			0.992	0.880	0.780				
January 17, 1908, a. m.			1.012	0.717					
January 30, 1908, a. m.			1.238	1.145	1.060	0.980	0.907		
January 10, 1910, a. m.			1.309	1.232	1.159	1.091	1.008		
A. M. means			**1.138**	**0.994**	**1.000**	**1.036**	**0.958**		
January 9, 1906, p. m.			1.279	1.155	1.069	0.943	0.852	0.770	
January 10, 1906, p. m.			1.259	1.175	1.097	1.024	0.956	0.912	0.871
January 29, 1906, p. m.			1.228	1.106	1.002	0.930			
January 30, 1906 p. m.			0.976	0.855	0.774	0.644			
January 21, 1907, p. m.			1.276	1.186	1.102	1.026	0.960	0.901	0.844
January 23, 1907, p. m.			1.311	1.202	1.123	1.048	0.978	0.914	
January 28, 1907, p. m.			0.980	0.912	0.850	0.792	0.738	0.688	0.643
January 3, 1908, p. m.				0.822	0.673	0.599	0.534	0.474	0.422
January 9, 1908, p. m.			1.146	1.059	0.978	0.904	0.836	0.773	0.754
January 14, 1908, p. m.			1.220	1.117	1.023	0.937	0.858	0.787	0.721
January 17, 1908, p. m.				1.020	0.921	0.742	0.683		
January 30, 1908, p. m.			1.267	1.180	1.098	1.022	0.952		
January 26, 1909, p. m.			1.181	0.969					
January 8, 1910, p. m.			0.922	0.994	0.946	0.800	0.677		
January 10, 1910, p. m.			1.251	1.163	1.082	1.007	0.937	0.889	0.829
January 19, 1910, p. m.			1.229	1.142	1.061	0.986	0.916	0.813	
P. M. means			**1.180**	**1.066**	**0.987**	**0.894**	**0.837**	**0.792**	**0.726**
January means			**1.171**	**1.062**	**0.989**	**0.910**	**0.853**	**0.792**	**0.726**
February 12, 1907, a. m.			1.217	1.119	1.029				
February 15, 1907, a. m.		1.376	1.165	0.986					
February 18, 1907, a. m.			1.337	1.243	1.154				
February 23, 1907, a. m.		1.308	1.262	1.157	1.062				
February 8, 1908, a. m.				1.086					
February 25, 1910, a. m.			1.128	1.020	0.922				
A. M. means		**1.342**	**1.222**	**1.102**	**1.042**				
February 3, 1906, p. m.			1.127	1.040	0.977	0.918			
February 6, 1906, p. m.			1.200						
February 13, 1906, p. m.		1.330	1.237	1.154	1.062	0.992	0.921	0.862	
February 15, 1906, p. m.		1.393	1.281	1.180	1.093	1.016	0.948		
February 26, 1906, p. m.		1.303		0.981	0.840				
February 15, 1907, p. m.		1.387	1.297	1.211	1.132	1.057	1.003		
February 25, 1907, p. m.		1.170	0.848	0.695	0.589	0.512			
February 6, 1908, p. m.			1.047	0.953	0.825				
February 8, 1908, p. m.		1.357	1.241	1.118	1.037	0.949			
February 1, 1909, p. m.			1.303	1.195	0.870				
February 6, 1909, p. m.			1.152	1.088	0.981	0.885			
February 8, 1909, p. m.			1.042						
February 11, 1909, p. m.			1.282	1.202	1.127	1.056	0.958	0.910	
February 17, 1909, p. m.		1.316	1.207	1.107	1.015	0.931	0.899		
February 1, 1910, p. m.			0.951	0.826	0.716	0.692	0.610	0.538	0.474
February 2, 1910, p. m.		1.181							
February 7, 1910, p. m.		1.343	1.253	1.170	1.092	0.919	0.869	0.822	
February 10, 1910, p. m.		1.389							
February 25, 1910, p. m.		1.297	1.189	1.090	0.999	0.938	0.881	0.828	0.778
P. M. means		**1.315**	**1.166**	**1.067**	**0.957**	**0.905**	**0.886**	**0.792**	**0.626**
February means		**1.319**	**1.179**	**1.077**	**0.975**	**0.905**	**0.886**	**0.792**	**0.626**
March 23, 1906, a. m.		1.113							
March 16, 1907, a. m.		0.976	0.791						
March 7, 1910, a. m.		1.328	1.225	1.146	1.050				
A. M. means		**1.139**	**1.008**	**1.146**	**1.050**				

TABLE 2.—*Washington pyrheliometer readings, etc.*—Continued.

Date.	Air mass.								
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
March 22, 1906, p. m.		1.214	1.108	1.032	0.919				
March 2, 1907, p. m.		1.282	1.206	1.133	1.064				
March 15, 1907, p. m.		1.308	1.131	1.024	0.928	0.835	0.765	0.702	
March 20, 1907, p. m.		1.299	1.197	1.107	1.022	0.950	0.884		
March 23, 1907, p. m.			0.922	0.780					
March 25, 1907, p. m.		1.300	1.200	1.108	1.022				
March 29, 1907, p. m.			0.756	0.615					
March 5, 1909, p. m.		1.280	1.176	1.079	0.992	0.910			
March 18, 1909, p. m.		1.157	1.019	0.973	0.850				
March 20, 1909, p. m.		1.126	0.990	0.870					
March 23, 1909, p. m.		1.275	1.153	1.044	0.944	0.855	0.774		
March 7, 1910, p. m.			1.163	1.038	0.935	0.839	0.752		
March 21, 1910, p. m.		1.266	1.104	0.999	0.904	0.819	0.742	0.677	
P. M. means		**1.251**	**1.087**	**0.985**	**0.958**	**0.868**	**0.783**	**0.690**	
March means		**1.225**	**1.076**	**0.996**	**0.966**	**0.868**	**0.783**	**0.690**	
April 3, 1906, a. m.		1.054							
April 12, 1906, a. m.		1.220							
April 13, 1906, a. m.		0.968							
April 16, 1906, a. m.		1.320	1.183	1.109					
April 17, 1906, a. m.	1.268	1.110	0.971	0.850					
April 18, 1906, a. m.	1.299	1.117	0.960						
April 24, 1906, a. m.		1.132							
April 28, 1906, a. m.	1.212	0.919							
April 2, 1907, a. m.	1.471	1.370	1.276	1.188	1.107				
April 3, 1907, a. m.		1.112	0.846						
April 25, 1907, a. m.		1.014	0.871	0.749					
April 17, 1908, a. m.		1.052	0.934	0.828	0.735				
April 28, 1909, a. m.	1.439	1.315	1.201	1.098	1.003				
A. M. means	**1.338**	**1.131**	**1.030**	**0.970**	**0.948**				
April 2, 1906, p. m.		1.295	1.180	1.075	0.979				
April 3, 1906, p. m.		1.288							
April 17, 1906, p. m.	1.257	1.097	0.956	0.865					
April 18, 1906, p. m.		1.127							
April 28, 1906, p. m.		0.927	0.776						
April 2, 1907, p. m.		1.306	1.197	1.097	1.005				
April 3, 1907, p. m.		0.982	0.813	0.674					
April 24, 1907, p. m.	1.328	1.163	1.018						
April 25, 1907, p. m.	1.210	1.099	0.991	0.893	0.805				
April 4, 1908, p. m.		1.131	0.977	0.846					
April 11, 1908, p. m.	1.301	1.198	1.082	0.978	0.883				
April 13, 1908, p. m.		1.043							
April 16, 1908, p. m.	1.403	1.257	1.106	0.998	0.900	0.811	0.733		
April 21, 1908, p. m.	1.428	1.243	1.081	0.940	0.817				
April 29, 1908, p. m.	1.312	1.133	0.979	0.845					
April 24, 1909, p. m.	1.326	0.954	0.840						
April 26, 1909, p. m.	1.355	1.232	1.083	0.950	0.833				
April 8, 1910, p. m.		1.074	0.960	0.828	0.596				
April 14, 1910, p. m.	1.253	1.077	0.926	0.795	0.683				
P. M. means	**1.317**	**1.138**	**0.998**	**0.906**	**0.833**	**0.811**	**0.733**		
April means	**1.324**	**1.135**	**1.009**	**0.927**	**0.862**	**0.811**	**0.733**		
May 29, 1906, a. m.	1.380	1.230	1.096	0 977					
May 13, 1907, a. m.	1.276	1.110	0.965	0.840					
May 14, 1907, a. m.		0.932							
May 22, 1907, a. m.		0.783							
May 1, 1908, a. m.		1.185	1.038	0.980					
May 4, 1909, a. m.	1.341	1.250	1.143	1.040	0.946				
May 12, 1909, a. m.	1.354	1.255	1.164						
May 17, 1909, a. m.		1.144	1.009	0.890					
A. M. means	**1.338**	**1.111**	**1.069**	**0.945**	**0.946**				

TABLE 2.—*Washington pyrheliometer readings, etc.*—Continued.

Date.	Air mass.								
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
May 8, 1906, p. m.	1.199	1.078	0.868	0.759					
May 17, 1906, p. m.	1.016								
May 18, 1906, p. m.	1.114	0.930	0.775	0.647					
May 25, 1906, p. m.	1.222								
May 29, 1906, p. m.	1.374	1.244	1.130	1.057					
May 13, 1907, p. m.		1.128	0.982	0.855	0.745				
May 14, 1907, p. m.	1.192	1.052	0.901						
May 21, 1907, p. m.		1.070	0.874						
May 26, 1908, p. m.	1.268								
May 4, 1909, p. m.		1.116	1.001						
May 12, 1909, p. m.		1.224	1.115						
P. M. means	**1.198**	**1.105**	**0.956**	**0.830**	**0.745**				
May means	**1.249**	**1.108**	**1.004**	**0.894**	**0.846**				
June 2, 1908, a. m.	1.345	1.201	1.073	0.959	0.856				
June 27, 1908, a. m.	1.268	1.052	0.901	0.754	0.740				
A. M. means	**1.306**	**1.126**	**0.987**	**0.856**	**0.798**				
June 27, 1905, p. m.	1.259	1.063	0.896						
June 22, 1906, p. m.	1.236	1.088							
June 17, 1907, p. m.	0.755	0.520							
June 8, 1908, p. m.	1.301	1.081	0.934	0.806	0.696				
June 16, 1908, p. m.	1.320	1.197	1.111	1.013	0.923				
June 24, 1908, p. m.	1.193	1.036							
June 18, 1909, p. m	1.284	1.214	1.099	0.995	0.901				
P. M. means	**1.193**	**1.028**	**1.010**	**0.938**	**0.840**				
June means	**1.218**	**1.050**	**1.003**	**0.905**	**0.823**				
July 3, 1907 a. m.		0.970							
July 27, 1907, a. m.	1.313	1.165	1.034	0.918					
July 31, 1907, a. m.		1.084							
July 6, 1908, a. m.	1.245								
July 11, 1908, a. m.	1.115	1.070	1.060	0.917	0.882				
July 16, 1908, a. m.	1.410	1.263	1.168	1.067	0.975				
July 4, 1909, a. m.		1.220	1.112	1.014	0.923				
July 8, 1909 a. m.	1.313	1.162	1.028	0.910	0.758				
July 19. 1909, a. m.		1.249	1.156	1.070	0.989	0.916			
A. M. means	**1.279**	**1.148**	**1.093**	**0.983**	**0.905**	**0.916**			
July 17, 1905, p. m.	1.122	1.009	0.861						
July 18, 1905, p. m.		1.028							
July 25, 1905, p. m.		0.935	0.910						
July 26, 1905, p. m.		1.001							
July 31, 1906, p. m.	1.015								
July 1, 1907, p. m.		0.836							
July 8, 1907, p. m.		0.865							
July 31, 1907, p. m.		1.005							
July 11, 1908, p. m.		0.982	0.800	0.654	0.534				
P. M. means	**1.068**	**0.958**	**0.857**	**0.654**	**0.534**				
July means	**1.219**	**1.053**	**1.014**	**0.936**	**0.844**	**0.916**			
August 15, 1907, a. m.		0.996							
August 19, 1907, a. m.		0.926							
August 21, 9107, a. m.		0.904							
August 26, 1907, a. m.		1.064							
August 2, 1908, a. m.		1.209	1.059	0.929	0.814				
August 3, 1908, a. m.	1.071	0.938							
August 4, 1908, a. m.	1.118	1.002							
August 11, 1909, a. m.	1.336	1.266	1.155	1.054	0.962	0.877			
August 25, 1909, a. m.		0.921							
A. M. means	**1.175**	**1.025**	**1.107**	**0.992**	**0.888**	**0.877**			

TABLE 2.—*Washington pyrheliometer readings, etc.*—Continued.

Date.	Air mass.								
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
August 22, 1905, p. m.		0.927	0.875						
August 2, 1907, p. m.		0.950							
August 26, 1907, p. m.		0.974							
August 2, 1908, p. m.	1.271	1.072	0.958	0.830	0.719				
August 4, 1908, p. m.		1.043							
August 25, 1909, p. m.	1.098	0.983	0.875						
P. M. means	**1.184**	**0.992**	**0.903**	**0.830**	**0.719**				
August means	**1.179**	**1.012**	**0.984**	**0.938**	**0.832**	**0.877**			
September 16, 1908, a. m.	1.367	1.263	1.169	1.081	1.001				
September 29, 1908, a. m.		1.270	1.124	0.997	0.881				
September 30, 1908, a. m.			0.878	0.751	0.642				
September 25, 1909, a. m.		1.286	1.241	1.159	1.081	1.009			
September 28, 1909, a. m.		1.335	1.245						
September 29, 1909, a. m.		1.154							
September 30, 1909, a. m.		1.112							
A. M. means	**1.367**	**1.237**	**1.131**	**0.997**	**0.901**	**1.009**			
September 19, 1905, p. m.		1.109	1.014						
September 21, 1905, p. m.		1.097	0.923						
September 22, 1905, p. m.		1.041	0.900						
September 26, 1905, p. m.		1.250	1.132	1.026	0.929				
September 28, 1905, p. m.		1.079	0.887						
September 7, 1906, p. m.		0.936	0.788						
September 25, 1906, p. m.		1.119	1.036						
September 8, 1908, p. m.	1.275	1.138	1.016	0.909					
September 9, 1908, p. m.	1.253	1.090	0.948	0.826					
September 29, 1908, p. m.		1.243	1.093	1.049	0.961	0.873			
September 30, 1908, p. m.		1.076	0.966	0.846	0.741	0.650			
September 28, 1909, p. m.		1.231	1.084	1.002	0.938				
September 29, 1909, p. m.			1.073	0.955	0.849				
September 30, 1909, p. m.		1.271	1.167	1.072	0.984	0.904			
P. M. means	**1.264**	**1.129**	**1.002**	**0.961**	**0.900**	**0.809**			
September means	**1.298**	**1.163**	**1.036**	**0.978**	**0.901**	**0.859**			
October 9, 1907, a. m.			1.158	1.062	0.975				
October 2, 1908, a. m.			1.147	0.994	0.861				
October 3, 1908, a. m.		1.298	1.199	1.106	1,020				
October 5, 1908, a. m.		1.032	0.894	0.775	0.671				
October 12, 1908, a. m.		1.292	1.155	1.045	0.947				
October 13, 1908, a. m.		1.143	0.971	0.826	0.703				
October 31, 1908, a. m.		1.311	1.194	1.087	0.990	0.902			
October 1, 1909, a. m.		1.196	1.086						
October 2, 1909, a. m.		1.080							
October 6, 1909, a. m.		1.059	0.888						
October 13, 1909, a. m.		1.252	1.158	1.073					
October 22, 1909, a. m.		1.303	1.183	1.076					
A. M. means		**1.197**	**1.094**	**1.005**	**0.881**	**0.902**			
October 4, 1905, p. m.		1.082	0.973	0.871	0.780	0.700	0.617		
October 5, 1905, p. m.		1.123	0.982	0.857	0.767	0.655	0.573		
October 7, 1905, p. m.		1.164		1.005	0.959				
October 9, 1905, p. m.		1.062			0.719	0.565			
October 13, 1905, p. m.		1.253	1.127	1.012	0.909	0.817	0.733	0.657	
October 8, 1906, p. m.		1.235	1.086	0.954	0.838				
October 12, 1906, p. m.		1.218	1.141	1.068	1.000	0.937	0.878	0.822	0.769
October 15 1906, p. m.		1.188	1.074	0.970	0.879	0.804	0.735		
October 26, 1906, p. m.		1.022	0.951	0.668	0.626	0.591	0.545	0.513	
October 2, 1907, p. m.		1.146	1.033	0.931	0.852	0.781			
October 7, 1907, p. m.		1.098	0.971	0.860					
October 8, 1907, p. m.			1.185	1.085	0.993	0.916	0.850	0.786	0.668
October 9, 1907, p. m.		1.182	1.060		0.837		0.743	0.702	
October 10, 1907, p. m.		1.085	0.944	0.821	0.714	0.621		0.469	
October 11, 1907, p. m.			0.916						
October 15, 1907, p. m.		1.081	0.941	0.818	0.712	0.620	0.539	0.469	0.407
October 2, 1908, p. m.		1.298	1.177	1.067	0.967	0.877			

TABLE 2.—*Washington pyrheliometer readings, etc.*—Continued.

Date.	Air mass.								
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
October 3, 1908, p. m.		1.307	1.215	1.130	1.051	0.980	0.934		
October 4, 1908, p. m.		1.223	1.195	1.110	1.031	0.958	0.890		
October 5, 1908, p. m.		1.066	0.934	0.817	0.716	0.627			
October 6, 1908, p. m.		1.110	1.125	1.024	0.932	0.848	0.773	0.704	
October 12, 1908, p. m.		1.373	1.276	1.186	1.102	1.024	0.965	0.904	
October 31, 1908, p. m.		1.311	1.194	1.087	0.990	0.902			
October 1, 1909, p. m.		1.136	1.007	0.893	0.791	0.701			
October 7, 1909, p. m.		1.090	0.938	0.860	0.790	0.725	0.666		
October 9, 1909, p. m.		0.896							
October 15, 1909, p. m.		1.167							
October 19, 1909, p. m.			1.239	1.151	1.072	1.003	0.940	0.879	
October 22, 1909, p. m.			1.181	1.080	0.988	0.904	0.847		
October 25, 1909, p. m.		1.356	1.222	1.102	0.994	0.896	0.841	0.804	
October 29, 1909, p. m.		1.359	1.112	0.911	0.747	0.612			
P. M. means		**1.172**	**1.081**	**0.975**	**0.880**	**0.794**	**0.769**	**0.701**	**0.615**
October means		**1.178**	**1.085**	**0.982**	**0.880**	**0.799**	**0.769**	**0.701**	**0.615**
November 2, 1906, a. m.		1.357	1.266	1.181	1.101				
November 3, 1906, a. m.		1.378	1.290	1.208	1.130				
November 6, 1906, a. m.		1.372	1.227	1.110	1.008				
November 7, 1906, a. m.		1.381	1.300	1.224	1.151				
November 5, 1908, a. m.			1.064	0.957	0.896	0.824			
November 12, 1908, a. m.			1.283	1.200	1.123				
November 17, 1908, a. m.			1.198	1.113					
November 27, 1908, a. m.			1.266	1.198					
November 18, 1909, a. m.				1.132	1.089				
November 26, 1909, a. m.			1.154	1.051	0.956	0.870			
November 27, 1909, a. m.			1.214	1.125	1.057	0.905			
A. M. means		**1.372**	**1.226**	**1.136**	**1.067**	**0.866**			
November 1, 1905, p. m.			1.064	0.982	0.911	0.824	0.745	0.695	
November 2, 1905, p. m.			0.959	0.837					
November 14, 1905, p. m.			1.220	1.121	1.030	0.946	0.865		0.746
November 17, 1905, p. m.				1.069					
November 21, 1905, p. m.			1.268	1.173	1.085				0.792
November 23, 1905, p. m.			1.188	1.125	1.054				0.794
November 25, 1905, p. m.			0 973	0.934	0.894				
November 1, 1906, p. m.		1.413	1.284	1.176	1.086	1.005	0.931	0.863	0.801
November 2, 1906, p. m.		1.343	1.245	1.153	1.068	0.989	0.916	0.848	0.786
November 3, 1906, p. m.		1.396	1.292	1.195	1.107	1.040	0.970	0.904	0.843
November 6, 1906, p. m.		1.393	1.265	1.159	1.061	0.972	0.891	0.815	0.747
November 7, 1906, p. m.		1.358	1.246	1.143	1.050	0.962	0.883	0.810	0.743
November 22, 1906, p. m.			1.296	1.215	1.139	1.073	1.017	0.964	0.914
November 24, 1906, p. m.				0.894	0.801	0.717	0.641		
November 27, 1906, p. m.			1.201				0.783	0.704	0.632
November 15, 1907, p. m.			0.951		0.741	0.655	0.578	0.511	0.451
November 12, 1908, p. m.			1.132	1.027	0.930	0.844	0.766	0.694	
November 18, 1908, p. m.			0.983	0.856	0.697	0.601	0.519		
November 5, 1909, p. m.			0.913	0.745	0.608	0.496	0.404		
November 17, 1909, p. m.			1.163	0.990	0.970	0.887	0.810	0.740	
November 26, 1909, p. m.			1.155	1.062	0.976	0.897	0.824	0.784	0.712
November 27, 1909, p. m.			1.214	1.041	0.892	0.764	0.655	0.560	0.542
November 29, 1909, p. m.			1.231	1.208	1.133	1.065	0.999	0.938	0.880
November 30, 1909, p. m.			1.271	1.181	1.100	1.025	0.954	0.889	0.827
P. M. means		**1.381**	**1.160**	**1.058**	**0.968**	**0.876**	**0.797**	**0.781**	**0.747**
November means		**1.377**	**1.180**	**1.084**	**0.995**	**0.874**	**0.797**	**0.781**	**0.747**
December 12, 1906, a. m.			1.000	0.977	0.912	0.977	0.977		
December 1, 1909, a. m.			1.232	1.138	1.051	0.970	0.896		
December 2, 1909, a. m.			1.235	1.180	1.127	1.045			
December 9, 1909, a. m.				1.170	1.038	0.920	0.816		
December 18, 1909, a. m.			1.157	1.119	1.083	1.048	0.991		
December 23, 1909, a. m.			1.105	0.992	0.891	0.799			
A. M. means			**1.146**	**1.096**	**1.017**	**0.960**	**0.920**		

TABLE 2.—*Washington pyrheliometer readings, etc.*—Continued.

Date.	Air mass.								
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
December 22, 1905, p. m	....	....	1.211	1.111	1.019	....	....	....	....
December 26, 1905, p. m	....	....	1.200	1.104	1.014	0.960	0.902	0.827	0.794
December 5, 1907, p. m	....	....	1.122	1.008	0.959	0.886	0.805	....	0.568
December 6, 1907, p. m	....	....	1.012	0.930	0.855	0.786	0.724	0.682	0.612
December 31, 1907, p. m	....	....	1.259	1.167	1.081	1.002	0.929	0.861	0.797
December 2, 1908, p. m	....	....	1.091	1.005	0.927	0.854	0.788	0.727	0.671
December 8, 1908, p. m	....	....	1.168	1.103	1.034	0.955	0.849	....	....
December 23, 1908, p. m	....	....	1.341	1.251	1.167	1.096	1.041	0.988	....
December 1, 1909, p. m	....	....	1.278	1.192	1.110	1.034	0.987	0.928	0.873
December 2, 1909, p. m	....	....	1.192	1.103	1.020	0.942	0.872	0.807	0.747
December 3, 1909, p. m	....	....	0.883	0.757	0.649	0.556	0.477	....	....
December 9, 1909, p. m	....	....	1.271	1.192	1.116	1.045	0.941	0.863	0.792
December 30, 1909, p. m	....	....	1.295	1.123	1.030	0.950	....	....	....
P. M. means	....	....	1.179	1.080	0.999	0.922	0.847	0.835	0.732
December means	....	....	1.170	1.085	1.004	0.935	0.866	0.835	0.732

Date. Air mass.	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0
November 29, 1909, p. m	0.804	0.720	0.653	0.592	0.531	0.491	0.454	0.422
November 30, 1909, p. m	0.748	0.689	0.638	0.585	0.542	0.495	0.459	0.423
December 1, 1909, p. m	0.787	0.719	0.656	0.599	0.546	0.501	0.454	0.414
December 2, 1909, p. m	0.624	....	....	....	....	....	....	....

Date. Air mass.	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0
November 29, 1909, p. m	0.393	0.365	0.340	0.313	0.292	0.272	0.254	0.236
November 30, 1909, p. m	0.392	0.360	....	....	....	....	....	....
December 1, 1909, p. m	0.378	0.344	0.313	0.286	0.261	0.238	0.217	0.198

Date. Air mass.	22.0	23.0	24.0	25.0	26.0	27.0	28.0	29.0
November 29, 1909, p. m	0.219	0.203	0.189	0.176	0.164	0.152	0.142	0.131
December 1, 1909, p. m	0.181	0.166	0.152	0.139	0.127	....	....	....

In order that the observations obtained from day to day may be comparable they have been reduced, when necessary, to their probable values for a series of air masses expressed in multiples of a half unit; the unit, as already stated, being the mass of the atmosphere at the zenith.

This reduction is easily accomplished graphically by plotting the observations on millimeter cross-section paper in the manner shown in fig. 1, each millimeter representing 0.01 of air mass or 0.001 in the logarithm of the radiation intensity. With a clear sky interpolations made necessary by this reduction are not appreciably in error, except for air masses greater than 3.0, and even then they will rarely amount to more than 1 per cent. It will be noted that the observations plot in curves that are slightly concave upward.

TABLE 3.—*Maximum solar radiation as observed for different hour angles of the sun and for corresponding air masses (m), reduced to mean solar declination for the month, and expressed in gram-calories per minute per square centimeter of normal surface.*

	Hour angle of sun in hours of mean time.												Hour angle at sunrise or sunset.	Mean radius vector of the earth.	Average. δ
	0	1.0	2.0	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0			
															° ′
January *m*	1.98	2.06	2.43	3.37	4.90	7.64	14.66						4.9	0.968	−20 45
A. M. radiation	1.31	1.30	1.24	1.11	0.88	0.68	0.35								
P. M. radiation	1.31	1.30	1.22	1.06	0.88										
February *m*	1.62	1.68	1.94	2.52	3.08	4.13	6.44	14.85					5.4	0.976	−12 57
A. M. radiation	1.37	1.36	1.34	1.24	1.14	0.99	0.77	0.43							
P. M. radiation	1.37	1.35	1.31	1.21	1.12	0.97									
March *m*	1.32	1.37	1.53	1.89	2.20	2.69	3.52	5.49	9.55				5.9	0.990	− 1 53
A. M. radiation	1.37	1.36	1.32	1.25	1.19	1.10	0.96	0.74	0.41						
P. M. radiation	1.34	1.33	1.30	1.24	1.18	1.10	0.95								
April *m*	1.13	1.18	1.30	1.54	1.74	2.03	2.48	3.16	4.76	8.81	34.16		6.6	1.007	+ 9 42
A. M. radiation	1.44	1.43	1.41	1.36	1.32	1.27	1.19	1.08	0.89	0.59	0.16				
P. M. radiation	1.40	1 38	1.36	1.29	1.26	1.19	1.10	0.94							
May *m*	1.07	1.10	1.19	1.38	1.54	1.75	2.06	2.52	3.33	4.83	8.76	30.33	7.1	1.022	+18 49
A. M. radiation	1.38	1.36	1.33	1.28	1.25	1.20	1.13	1.04	0.89	0.70	0.44	0.12			
P. M. radiation	1.36	1.35	1.32	1.27	1.23	1.18	1.12	1.06							
June *m*	1.05	1.07	1.16	1.33	1.47	1.65	1.93	2.30	2.93	4.01	6.32	9.62	7.4	1.032	+23 4
A. M. radiation	1.33	1.32	1.30	1.25	1.21	1.16	1.09	1.00	0.87	0.71	0.50	0.25			
P. M. radiation	1.31	1.30	1.28	1.25	1.22	1.18	1.12	1.07	0.94						
July *m*	1.06	1.08	1.17	1.35	1.50	1.70	1.98	2.38	3.05	4.33	7.19	18.44	7.3	1.033	+21 13
A. M. radiation	1.39	1.38	1.36	1.31	1.26	1.22	1.17	1.09	0.99	0.79	0.55	0.24			
P. M. radiation	1.11	1.10	1.09	1.05	1.03	0.98	0.91	0.70	0.52						
August *m*	1.10	1.14	1.25	1.47	1.65	1.89	2.28	2.80	3.98	6.47	15.76		6.8	1.025	+13 44
A. M. radiation	1.32	1.31	1.30	1.27	1.23	1.18	1.10	1.00	0.83	0.59	0.28				
P. M. radiation	1.26	1.24	1.20	1.10	1.05	0.98	0.88	0.76							
September *m*	1.23	1.28	1.42	1.72	1.98	2.36	2.98	4.00	7.13	20.59			6.2	1.010	+ 2 58
A. M. radiation	1.35	1.35	1.34	1.29	1.25	1.18	1.08	0.94	0.67	0.20					
P. M. radiation	1.32	1.31	1.29	1.22	1.17	1.10	0.99								
October *m*	1.48	1.54	1.75	2.22	2.65	3.41	4.97	8.90	29.99				5.6	0.993	− 8 40
A. M. radiation	1.31	1.30	1.25	1.15	1.08	0.92									
P. M. radiation	1.38	1.36	1.32	1.24	1.16	1.04	0.83	0.59	0.08						
November *m*	1.84	1.92	2.24	3.04	3.84	5.54	9.96	39.71					5.0	0.978	−18 10
A. M. radiation	1.32	1.31	1.26	1.16											
P. M. radiation	1.33	1.31	1.26	1.13	1.03	0.83	0.53								
December *m*	2.13	2.22	2.64	3.76	5.10	8.28	21.90						4.7	0.968	−23 0
A. M. radiation	1.22	1.21	1.16	1.03											
P. M. radiation	1.32	1.30	1.23	1.06	0.93	0.63	0.22								

In the last column of Table 3 is given the average declination of the sun, δ, for each month. On the same line with the value of δ are given the values of the air mass, m, corresponding with this value of δ and different hour angles of the sun from the meridian of Washington. In the two following lines for each month are given the maximum observed intensities of solar radiation on a unit of normal surface for morning and afternoon hours, respectively, reduced to this average value of δ. The reductions have been effected by plotting the maximum a. m. and p. m. values for each month as obtained from Table 2 in the manner shown in fig. 1. Since the maxima for the morning or for the afternoon hours of any month have usually all occurred on the same day they have generally plotted in curves as smooth as those for November 22, 1906, or for February 15, 1907, shown on fig. 1. The data corresponding to the air masses indicated in the table have been read off from the curve that best fits the plotted data. Where a difference exists between the maxima at noon for the a. m. and the p. m. series it is due to the fact that they have been obtained on different days.

The monthly mean values of radiation given in Table 2 have been similarly plotted, and smoothed curves drawn through the plotted data. From the points on these curves corresponding to the values of m given in Table 3, have been obtained the mean radiation values corresponding to different hour angles as given in Table 4. The means of Table 2 do not plot on so smooth a curve as do the maximum values, but in only a few cases do individual means depart from a smoothed curve by more than 2 per cent, except for air masses greater than 3.5.

TABLE 4.—*Monthly mean solar radiation expressed in gram-calories per minute per square centimeter of normal surface, as observed for different hour angles of the sun.*

Month.	Hour angle of sun in hours of mean time.											
	0	1.0	2.0	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
January	1.16	1.15	1.08	0.93	0.74	0.54	0.28	......	......	......	......	......
February	1.28	1.26	1.20	1.08	0.97	0.93	0.81	0.42	......	......	......	......
March	1.26	1.24	1.20	1.13	1.07	0.98	0.85	0.64	0.34	......	......	......
April	1.26	1.24	1.20	1.13	1.07	1.00	0.93	0.84	0.66	0.41	0.10	......
May	1.23	1.22	1.19	1.14	1.10	1.05	0.99	0.90	0.80	0.62	0.39	0.10
June	1.20	1.20	1.18	1.14	1.11	1.07	1.01	0.94	0.83	0.67	0.48	0.24
July	1.21	1.20	1.18	1.14	1.11	1.05	1.02	0.95	0.84	0.68	0.49	0.24
August	1.16	1.15	1.13	1.09	1.05	1.01	0.94	0.86	0.74	0.55	0.27	......
September	1.23	1.22	1.18	1.11	1.04	0.99	0.91	0.80	0.57	0.22	......	......
October	1.19	1.18	1.13	1.03	0.95	0.83	0.63	0.40	0.11	......	......	......
November	1.23	1.21	1.14	0.97	0.84	0.70	0.44	0.04	......	......	......	......
December	1.15	1.13	1.06	0.90	0.73	0.51	0.20	......	......	......	......	......

Air masses have generally been read from a diagram prepared by computations from the equation

$$m = \frac{\text{atmospheric refraction (in seconds)}}{58.36'' \times \sin Z}$$

where m = the air mass, and Z = the zenith distance of the sun. But in cases where the value of m or of the sun's hour angle has exceeded 5.0 recourse has been had to Ball's Altitude Tables[32] to determine the zenith distance of the sun, and to tables published by Bemporad[33] for obtaining the corresponding air mass.

GENERAL RESULTS.

Diurnal march of radiation.—The a. m. and p. m. means of Table 2, as well as the maxima in Table 3, show that from April to September, inclusive, the radiation during the morning hours is generally in excess of that during the corresponding afternoon hours, but that the difference is slight during the remainder of the year. The p. m. deficiency is especially pronounced in July.

On clear days there is little evidence of a noon minimum in the diurnal radiation curve, such as has been noted at several observatories, and especially at Montpellier, France.[34] However, on days when cumulus clouds form, the midday depression is often marked.

Annual march of radiation.—Table 3 shows a rather surprising uniformity throughout the year in the maximum intensity of radiation, the December minimum being only 8 per cent less than the April maximum. Table 4 shows maxima in the spring and fall, and minima in August and December, the December minimum being 10 per cent lower than the February maximum.

Daily totals of radiation received on a normal surface.—By plotting the data of Tables 3 and 4 on cross-section paper we effect a graphical integration of the amount of solar radiation received on a normal surface at Washington during a day of average declination of the sun for each month, both for the clearest sky that has been observed, and also for a sky of average clearness but without clouds.

In effecting this integration it is necessary to plot the data for half-day periods only. For the maximum rates, therefore, the p. m. data have been selected for the months of October, November, and December, since in general the observations after noon have covered a greater range of hour angles than have the morning observations; but for the remaining months of the year the a. m. data have been employed, since the object sought is the quantity of radiation that is received when the sky is clearest.

The results of the above indicated integrations multiplied by two are shown in columns 2 and 4 of Table 7.

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[32] Altitude Tables by Frederick Ball, London, 1907.

[33] Rendiconti della R. Accademia dei Lincei, 1907, Vol. 16, 2d semester, p. 69.

[34] Hann, Lehrbuch der Meteorologie, Zweite Auflage, p. 31.

Only a limited number of observations are available for determining the rate of radiation corresponding to air masses greater than 5.0. Three excellent series which were continued up to the time of sunset were obtained in November and December, 1909, and are shown at the end of Table 2. A few readings were also obtained at Asheville, N. C., in 1903, but on account of uncertainty as to the constants of the instruments employed they have not been considered here. It is believed, however, that the data used are sufficient to determine the form of the curve when the sun is near the horizon with sufficient accuracy so that the error in the totals resulting from this source does not amount to more than 1 per cent for any month of the year.

TABLE 5.—*Maximum observed solar radiation for different hour angles of the sun (and the corresponding zenith distances), expressed in gram-calories per minute per square centimeter of horizontal surface.*

Month.	Hour angle of sun in hours of mean time.											
	0	1.0	2.0	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
January.												
Z., degrees.....	59.6	61.0	65.8	72.91	78.48	82.87	86.79	......	......	......	......	......
A. M. radiation	0.664	0.628	0.508	0.325	0.176	0.084	0.020	......	......	......	......	......
February.												
Z., degrees.....	52.0	53.6	59.0	66.71	71.20	76.20	81.40	86.85	......	......	......	......
A. M. radiation	0.842	0.807	0.691	0.489	0.367	0.237	0.082	0.024	......	......	......	......
March.												
Z., degrees.....	41.2	43.0	49.4	58.10	63.14	68.36	73.67	79.78	84.46	......	......	......
A. M. radiation	1.028	0.992	0.861	0.661	0.539	0.407	0.270	0.131	0.039	......	......	......
April.												
Z., degrees.....	28.0	31.7	39.8	49.6	55.02	60.52	66.31	71.69	78.12	83.93	89.64	......
A. M. radiation	1.275	1.222	1.084	0.883	0.759	0.626	0.480	0.340	0.183	0.062	0.001	......
May.												
Z., degrees.....	20.7	24.9	32.9	43.8	49.5	55.2	61.98	66.66	72.67	78.30	83.89	89.33
A. M. radiation	1.287	1.229	1.120	0.927	0.810	0.685	0.530	0.411	0.265	0.142	0.047	0.001
June.												
Z., degrees.....	17.2	21.3	30.4	41.6	47.3	52.8	58.43	64.29	70.20	75.77	81.22	84.52
A. M. radiation	1.269	1.234	1.119	0.932	0.819	0.702	0.571	0.435	0.295	0.175	0.076	0.024
July												
Z., degrees.....	18.8	22.2	31.1	42.4	48.3	53.9	59.63	65.28	71.00	76.87	82.38	87.74
A. M. radiation	1.320	1.286	1.163	0.964	0.840	0.721	0.590	0.457	0.322	0.179	0.073	0.010
August.												
Z., degrees.....	25.1	28.8	36.8	47.2	52.7	58.15	64.16	69.23	75.65	81.44	87.11	......
A. M. radiation	1.196	1.152	1.041	0.862	0.745	0.621	0.478	0.354	0.205	0.088	0.014	......
September.												
Z., degrees.....	36.2	38.8	45.3	54.5	59.65	65.00	70.73	75.75	82.30	88.14	......	......
A. M. radiation	1.090	1.051	0.942	0.752	0.631	0.500	0.358	0.231	0.090	0.007	......	......
October.												
Z., degrees.....	47.8	49.7	55.2	63.3	68.25	73.10	78.65	84.00	89.30	......	......	......
P. M. radiation	0.924	0.882	0.755	0.555	0.430	0.302	0.164	0.062	0.001	......	......	......
November.												
Z., degrees.....	57.3	58.3	63.6	70.9	75.12	79.88	84.74	90.00	......	......	......	......
P. M. radiation	0.713	0.687	0.558	0.370	0.265	0.145	0.049	0.000	......	......	......	......
December.												
Z. degrees.....	62.1	63.4	67.8	74.72	78.95	83.48	88.35	......	......	......	......	......
P. M. radiation	0.616	0.582	0.464	0.279	0.178	0.072	0.004	......	......	......	......	......

Daily totals of radiation received on a horizontal surface.—Multiplying the data of Tables 3 and 4 by the cosine of the zenith distance of the sun for the different hour angles indicated, we obtain the rates at which solar radiation is received on a horizontal surface, shown in Tables 5 and

where m = the air mass, and Z = the zenith distance of the sun. But in cases where the value of m or of the sun's hour angle has exceeded 5.0 recourse has been had to Ball's Altitude Tables[32] to determine the zenith distance of the sun, and to tables published by Bemporad[33] for obtaining the corresponding air mass.

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Daily totals of radiation received on a normal surface.—By plotting the data of Tables 3 and 4 on cross-section paper we effect a graphical integration of the amount of solar radiation received on a normal surface at Washington during a day of average declination of the sun for each month, both for the clearest sky that has been observed, and also for a sky of average clearness but without clouds.

In effecting this integration it is necessary to plot the data for half-day periods only. For the maximum rates, therefore, the p. m. data have been selected for the months of October, November, and December, since in general the observations after noon have covered a greater range of hour angles than have the morning observations; but for the remaining months of the year the a. m. data have been employed, since the object sought is the quantity of radiation that is received when the sky is clearest.

The results of the above indicated integrations multiplied by two are shown in columns 2 and 4 of Table 7.

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[32] Altitude Tables by Frederick Ball, London, 1907.

[33] Rendiconti della R. Accademia dei Lincei, 1907, Vol. 16, 2d semester, p. 69.

[34] Hann, Lehrbuch der Meteorologie, Zweite Auflage, p. 31.

Only a limited number of observations are available for determining the rate of radiation corresponding to air masses greater than 5.0. Three excellent series which were continued up to the time of sunset were obtained in November and December, 1909, and are shown at the end of Table 2. A few readings were also obtained at Asheville, N. C., in 1903, but on account of uncertainty as to the constants of the instruments employed they have not been considered here. It is believed, however, that the data used are sufficient to determine the form of the curve when the sun is near the horizon with sufficient accuracy so that the error in the totals resulting from this source does not amount to more than 1 per cent for any month of the year.

TABLE 5.—*Maximum observed solar radiation for different hour angles of the sun (and the corresponding zenith distances), expressed in gram-calories per minute per square centimeter of horizontal surface.*

Month.	Hour angle of sun in hours of mean time.											
	0	1.0	2.0	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
January.												
Z., degrees.....	59.6	61.0	65.8	72.91	78.48	82.87	86.79	......	......	......	......	......
A. M. radiation	0.664	0.628	0.508	0.325	0.176	0.084	0.020	......	......	......	......	......
February.												
Z., degrees.....	52.0	53.6	59.0	66.71	71.20	76.20	81.40	86.85	......	......	......	......
A. M. radiation	0.842	0.807	0.691	0.489	0.367	0.237	0.082	0.024	......	......	......	......
March.												
Z., degrees.....	41.2	43.0	49.4	58.10	63.14	68.36	73.67	79.78	84.46	......	......	......
A. M. radiation	1.028	0.992	0.861	0.661	0.539	0.407	0.270	0.131	0.039	......	......	......
April.												
Z., degrees.....	28.0	31.7	39.8	49.6	55.02	60.52	66.31	71.69	78.12	83.93	89.64	......
A. M. radiation	1.275	1.222	1.084	0.883	0.759	0.626	0.480	0.340	0.183	0.062	0.001	......
May.												
Z., degrees.....	20.7	24.9	32.9	43.8	49.5	55.2	61.98	66.66	72.67	78.30	83.89	89.33
A. M. radiation	1.287	1.229	1.120	0.927	0.810	0.685	0.530	0.411	0.265	0.142	0.047	0.001
June.												
Z., degrees.....	17.2	21.3	30.4	41.6	47.3	52.8	58.43	64.29	70.20	75.77	81.22	84.52
A. M. radiation	1.269	1.234	1.119	0.932	0.819	0.702	0.571	0.435	0.295	0.175	0.076	0.024
July												
Z., degrees.....	18.8	22.2	31.1	42.4	48.3	53.9	59.63	65.28	71.00	76.87	82.38	87.74
A. M. radiation	1.320	1.286	1.163	0.964	0.840	0.721	0.590	0.457	0.322	0.179	0.073	0.010
August.												
Z., degrees.....	25.1	28.8	36.8	47.2	52.7	58.15	64.16	69.23	75.65	81.44	87.11	......
A. M. radiation	1.196	1.152	1.041	0.862	0.745	0.621	0.478	0.354	0.205	0.088	0.014	......
September.												
Z., degrees.....	36.2	38.8	45.3	54.5	59.65	65.00	70.73	75.75	82.30	88.14	......	......
A. M. radiation	1.090	1.051	0.942	0.752	0.631	0.500	0.358	0.231	0.090	0.007	......	......
October.												
Z., degrees.....	47.8	49.7	55.2	63.3	68.25	73.10	78.65	84.00	89.30	......	......	......
P. M. radiation	0.924	0.882	0.755	0.555	0.430	0.302	0.164	0.062	0.001	......	......	......
November.												
Z., degrees.....	57.3	58.3	63.6	70.9	75.12	79.88	84.74	90.00	......	......	......	......
P. M. radiation	0.713	0.687	0.558	0.370	0.265	0.145	0.049	0.000	......	......	......	......
December.												
Z. degrees.....	62.1	63.4	67.8	74.72	78.95	83.48	88.35	......	......	......	......	......
P. M. radiation	0.616	0.582	0.464	0.279	0.178	0.072	0.004	......	......	......	......	......

Daily totals of radiation received on a horizontal surface.—Multiplying the data of Tables 3 and 4 by the cosine of the zenith distance of the sun for the different hour angles indicated, we obtain the rates at which solar radiation is received on a horizontal surface, shown in Tables 5 and

6. A graphical integration of this vertical component of the solar radiation has also been effected in the same manner as for radiation at normal incidence, and the results are given in columns 6 and 8 of Table 7.

TABLE 6.—*Monthly mean observed solar radiation for different hour angles of the sun, expressed in gram-calories per minute per square centimeter of horizontal surface.*

Month.	Hour angle of sun in hours of mean time.											
	0	1.0	2.0	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
January	0.585	0.554	0.443	0.273	0.148	0.067	0.016	......	......	......	......	......
February	0.778	0.748	0.618	0.425	0.313	0.223	0.122	0.023	......	......	......	......
March	0.945	0.909	0.783	0.595	0.482	0.362	0.239	0.113	0.033	......	......	......
April	1.113	1.055	0.930	0.732	0.613	0 492	0.374	0.264	0.136	0.043	0.001	......
May	1.150	1.107	1.003	0.823	0.714	0.601	0.464	0.356	0.239	0.126	0.042	0.001
June	1.150	1.118	1.018	0.853	0.751	0.647	0.530	0.408	0.281	0.165	0.073	0.023
July	1.144	1.113	1.012	0.844	0.740	0.621	0.515	0.395	0.273	0.154	0.065	0.010
August	1.050	1.009	0.912	0.737	0.639	0.534	0.411	0.306	0.184	0.082	0.014	......
September	0.995	0.951	0.832	0.643	0.528	0.418	0.301	0.196	0.076	0.007	......	......
October	0.800	0.762	0.646	0.464	0.352	0.240	0.124	0.042	0.001	......	......	......
November	0.666	0.637	0.507	0.318	0.216	0.123	0.040	0.000	......	......	......	......
December	0.537	0.507	0.401	0.237	0.141	0.058	0.006	......	......	......	......	......

Monthly totals of solar radiation with a cloudless sky.—Multiplying the daily totals for each month in Table 7 by the corresponding number of days in the month, we obtain the maximum and the average monthly amounts of radiation that would be received, if no clouds were present, from the sun and also from a small portion of the sky immediately about it to which the pyrheliometric surfaces are exposed.

TABLE 7.—*Quantity of heat received from the sun at Washington with a clear sky, expressed in gram-calories per square centimeter.*

Month.	Normal surface.				Horizontal surface.				Percent of possible sunshine.
	Maximum rates.		Mean rates.		Maximum rates.		Mean rates.		
	Daily.	Monthly.	Daily.	Monthly.	Daily.	Monthly.	Daily.	Monthly.	
January	600.6	18619	518.0	16058	224.8	6969	192.9	5980	45.3
February	721.8	20210	661.3	18516	320.6	8977	292.4	8187	54.2
March	782.9	24270	705.7	21877	431.0	13361	386.8	11991	50.1
April	940.1	28203	769.6	23088	552.3	16569	488.7	14661	58.5
May	895.2	27751	823.6	25532	617.1	19130	550.8	17075	58.6
June	917.1	27513	841.4	25242	627.2	18816	573.5	17205	62.1
July	970.8	30095	847.9	26285	653.1	20246	567.6	17596	63.6
August	882.9	27370	775.7	24047	566.4	17558	488.2	15134	61.1
September	842.6	25278	733.1	21993	485.6	14568	422.8	12684	63.8
October	744.8	23089	620.0	19220	361.2	11197	307.5	9532	61.1
November	639.5	19185	552.7	16581	255.4	7662	220.6	6618	54.3
December	584.8	18129	502.8	15587	205.6	6374	176.2	5462	52.4

Actual monthly totals of solar radiation.—In order to obtain from eye readings of the pyrheliometer the actual amount of solar radiation received at a given place, it is necessary to take account of the cloudiness of the sky either by multiplying the daily or monthly amounts that would be received in the absence of all clouds by the recorded duration

of sunshine expressed as a fractional part of the possible duration for the period in question, or, more accurately, to multiply the amount of radiation that would be received each hour of the day with a cloudless sky by the average duration of sunshine for that hour.

In column 10 of Table 7 is given the average percentage of possible sunshine recorded at Washington for each month, deduced from records for the 16 years 1894 to 1909, inclusive. These records were obtained by the use of the thermometric sunshine recorder described in Instrument Division Circular G, U. S. Weather Bureau, which, if instructions are followed, is adjusted so that a record is obtained as long as the disk of the sun is directly visible through the clouds. Necessary corrections to the record with low angle of the sun have been determined by means of eye observations. The product of the rate of radiation from a cloudless sky by the ratio of the recorded duration of sunshine to the possible total gives too little actual radiation, since, as has been pointed out by Hann and others, a very considerable percentage of the radiation received on a horizontal surface is due to diffuse sky radiation. Indeed, photometric measurements indicate that with the sun less than 15° above the horizon the diffuse sky light exceeds the direct solar light. Very few measurements have been made of the relative amounts of heat received directly from the sun and diffusely from the sky, although Abbot found that on Mount Wilson under certain average conditions the diffuse radiation was 13.5 per cent of the direct solar radiation received on a horizontal surface.

The Callendar recording horizontal pyrheliomteer.—This consists of a pair of platinum thermometers wound on a horizontal mica plate fixed in a sealed glass bulb. One of the thermometers being coated with black enamel is raised to a higher temperature than the other by exposure to radiation. According to Callendar the difference of temperature of the two bulbs is very nearly proportional to the intensity of the radiation, and is automatically recorded by a Callender recorder. This recorder is a self-adjusting Wheatstone bridge, which automatically balances the resistances of the bulbs, and at the same time makes a record of the change that has taken place.

One of these instruments has been in operation at the Weather Bureau since August, 1909, although the record has suffered frequent interruptions. Its constants were furnished by the manufacturers, the Cambridge Scientific Instrument Company. Aside from some comparisons made by Callendar[34] between his absolute bolometer and an Ångström pyrheliometer, which showed a difference of only 1 per cent

[34] Proc. Royal soc., London, 1906, Ser. A. Vol. 77, p. 6.

between the indications of the two instruments, we have no means of judging of the agreement between the Ångström pyrheliometer and the Callendar recording horizontal pyrheliometer. However, the intensity of solar radiation at normal incidence, as measured by the Ångström pyrheliometer, has been reduced to the corresponding intensity on a horizontal surface by multiplying it by the cosine of the sun's zenith distance, and this latter has been compared with the intensity of the radiation received from the whole sky, including that portion occupied by the sun, as recorded by the Callendar instrument. In general the records made by the latter are in excess of the indications of the former by amounts ranging from 0 to 10 per cent at noon and from 10 to 50 per cent with the sun near the horizon. Especially good comparisons were obtained on August 11 and September 28 and 30, 1909, and the totals for each hour, and also for each half-day period, are given in Table 8. The atmospheric conditions were quite steady on August 11 until about 1 p. m. when the sky became rapidly overcast with cirrus clouds. The polarization observations indicate that on September 28 the sky was very clear in the morning, but became somewhat hazy in the afternoon, while on September 30 it was decidedly hazy during the morning, but became clear in the afternoon. The effect of the haziness on the morning of September 30 is clearly shown in Table 8 in the increased

TABLE 8.—*Total radiation, expressed in gram-calories per square centimeter of horizontal surface, as recorded by the Callendar horizontal pyrheliometer, and as measured by the Ångström pyrheliometer.*

True solar time.	August 11, 1909.				September 28, 1909.				September 30, 1909.			
	Callendar.	Ångström.	Difference.	Ratio Callendar / Ångström.	Callendar	Ångström.	Difference.	Ratio Callendar / Ångström.	Callendar.	Ångström.	Difference.	Ratio Callendar / Ångström.
5–6 a. m.	2.7	**1.7**	+1.0	......	......	......	......	......	......	......	......	......
6–7 a. m.	15.3	11.4	+3.9	1.34	8.4	**4.7**	+3.7	......	5.2	**2.5**	+2.7	......
7–8 a. m.	30.4	26.4	+4.0	1.15	21.7	16.8	+4.9	1.29	17.2	**7.4**	+9.8	......
8–9 a. m.	45.4	42.5	+2.9	1.07	37.8	33.1	+4.7	1.14	30.1	21.2	+8.9	1.42
9–10 a. m.	58.0	57.1	+0.9	1.02	48.4	46.9	+1.5	1.03	41.5	33.8	+7.7	1.23
10–11 a. m.	66.2	65.7	+0.5	1.01	57.1	56.3	+0.8	1.01	51.1	45.0	+6.1	1.14
11–12 a. m.	70.6	70.6	+0.0	1.00	62.0	61.0	+1.0	1.02	58.0	53.1	+4.9	1.09
12–1 p. m.	73.1	72.9	+0.2	1.00	61.5	60.0	+1.5	1.02	60.3	58.3	+2.0	1.03
1–2 p. m.	......	......	......	......	55.8	52.9	+2.9	1.05	56.6	53.1	+3.5	1.07
2–3 p. m.	......	......	......	......	45.2	42.0	+3.2	1.08	46.9	42.0	+4.9	1.12
3–4 p. m.	......	......	......	......	31.4	27.9	+3.5	1.13	32.6	29.1	+3.5	1.12
4–5 p. m.	......	......	......	......	15.1	13.6	+1.5	1.11	16.4	13.3	+3.1	1.23
5–6 p. m.	......	......	......	......	1.5	**1.7**	−0.2	......	2.2	**1.7**	+0.5	......
A. M. totals	288.6	275.4	......	1.05	235.4	218.8	......	1.08	203.1	163.0	......	1.25
P. M. totals	......	......	......	......	210.5	198.1	......	1.06	215.0	197.5	......	1.09
Daily totals	577.2	550.8	......	1.05	445.9	416.9	......	1.07	418.1	360.5	......	1.16

Note—Values in black face under Ångström have been interpolated.

difference between the indications of the Callendar and the Ångström instruments.

During October, 1909, there were 9 clear days on which observations were obtained with the Ångström pyrheliometer. The average total radiation on a square centimeter of horizontal surface for these 9 days as measured by this instrument was 311.2 calories per day, or only slightly in excess of the average for October given in column 8 of Table 7. The average amount recorded by the Callendar recorder for these same 9 days was 357 calories per day, or 15 per cent in excess of the amount given by the Ångström. This is slightly less than the excess recorded on September 30, and is not inconsistent with the results of measurements made by Abbot[35] on the quantity of light reflected diffusely from the sky at Mount Wilson, namely 13.5 per cent of the radiation received from the sun on a horizontal surface.

The records from the Callendar horizontal pyrheliometer for the months of August, September, and October, 1909, are complete except for a few hours, mostly on cloudy days, for which the data have been interpolated. The totals for each month, and for an average day in each month, are given in Table 9, together with corresponding totals obtained (1) from the products of the hourly averages of radiation taken from the data in Table 6 and the average recorded duration of sunshine for each hour of the day in the above-named months; and (2) from the products of the totals in columns 8 and 9 of Table 7 by the duration of sunshine in the corresponding months of 1909, the duration of sunshine in all cases being expressed as a fractional part of its possible duration.

TABLE 9.—*Total amount of radiation recorded by the Callendar pyrheliometer, and computed from observations with the Ångström pyrheliometer, during August, September, and October, 1909, expressed in gram-calories per square centimeter of horizontal surface.*

	Average daily radiation.			Total monthly radiation.		
	Aug.	Sept.	Oct.	Aug.	Sept.	Oct.
Callendar recorder	421.9	349.0	272.4	13079	10469	8445
Ångström (product of hourly averages of radiation and sunshine)	326.8	203.8	192.4	10131	6114	5964
Ångström (product of monthly totals of radiation and sunshine)	302.7	202.9	190.6	9383	6088	5910

The percentage of possible sunshine during September was 48, and was especially low during the morning hours. The percentage was 62

[35] Annals of the Astrophysical Observatory of the Smithsonian Institution, Vol. 2, p. 153.

for both August and October, and in August it was above the average during the middle of the day.

From Tables 8 and 9 it is apparent that a very considerable percentage of radiation is reflected diffusely from the sky and from the clouds that can not be neglected in computing the total radiation received on a horizontal surface at any given place. A more exact determination will not be attempted for Washington until a longer series of records from a horizontal pyrheliometer has been obtained.

TABLE 10.—*Maximum intensity of solar radiation observed at different stations.*

Stations.	Cape Horn.	Washington.	Montpellier.	Modena.	Modena.	Kief.
Latitude	S. 55° 31′	N. 38° 54′	N. 43° 36′	N. 44° 39′	N. 44° 39′	N. 50° 24′
Period	1882–1883.	1905–1910.	1883–1900.	1900.	1901–1903.	1888.
Instruments	Pouillet.	Ångström.	Crova.	Violle.	Ångström.	Crova.
January	1.47	1.31	1.36	....	1.20	....
February	1.37	1.37	1.38	....	1.02	....
March	0.99	1.37	1.36	1.30	1.33	1.32
April	1.10	1.44	1.43	1.25	1.28	....
May	0.88	1.38	1.54	1.24	1.26	1.39
June	0.96	1.33	1.46	1.20	1.22	1.26
July	0.93	1.39	1.42	1.30	1.37	....
August	0.88	1.32	1.60	1.32	1.28	1.29
September	1.39	1.35	1.43	1.21	1.32	1.27
October	1.36	1.38	1.37	1.21	1.19	1.17
November	1.25	1.32	1.36	1.19	1.13	1.11
December	1.37	1.32	1.26	....	1.16	1.13
Annual	1.47	1.44	1.60	1.32	1.37	1.39

Stations.	Warsaw.	Hald.	Katharinenburg.	Pavlovsk.	Upsala.	St. Petersburg.	Treurenberg.
Latitude	N. 52° 13′	N. 56° 23′	N. 56 50′	N. 59 41′	N. 59° 51′	N. 59° 56′	N. 79° 55′
Period	1901–1905.	1902–1903.	1896–1898.	1893–1906.	1901	1895–1904.	1899–1900.
Instruments	Chwolson.	Ångström.	Chwolson.	Chwolson.	Ångström.	Chwolson.	Ångström.
January	0.93	0.75	....	1.16	0.98	1.06	0.00
February	1.21	0.88	1.35	1.31	1.14	1.31	....
March	1.31	0.89	1.54	1.42	1.32	1.40	....
April	1.30	....	1.58	1.48	1.35	1.45	1.11
May	1.31	1.06	1.44	1.45	1.33	1.47	1.23
June	1.29	1.08	1.32	1.42	1.31	1.40	1.27
July	1 29	1.32	1.38	1.33	1.35	1.36	1.29
August	1.26	1.30	1.42	1.34	1.30	1.33	....
September	1.35	1.23	1.38	1.37	1.31	1.29	1.08
October	1.19	1.18	1.33	1.33	1.09	1.31	....
November	1.06	0.80	1.26	1.14	1.07	1.10	0.00
December	0.98	0.92	1 05	0.98	0.78	0.79	0.00
Annual	1.35	1.32	1.58	1.48	1.35	1.47	1.29

The fact that at noon on August 11, with clear sky and a high sun, the indications of the two instruments were very nearly in accord indicates that the unit of measure of the Callendar recorder may be a little larger than the unit of the Ångström instrument, and consequently that the quantity of energy here indicated as diffusely reflected from the sky and

the clouds may be too small. It is expected that an investigation of the constants of the Callendar recorder will be made in the near future.

INTENSITY OF RADIATION AT DIFFERENT STATIONS.

In Table 10 are collected from various sources[36] the maximum rates of radiation that have been observed at different stations. The Ångström instruments employed at Washington, Upsala, Treurenberg, Modena, and Hald had all been recently compared with Ångström's standard instrument, either directly or indirectly, and were therefore very closely in accord. The Chwolson instrument employed at Warsaw had also been standardized by comparison with an Ångström pyrheliometer. It is noticeable that in summer the maxima recorded at these six stations are in close agreement, ranging between 1.29 in July at Treurenberg and 1.44 at Washington in April. The maximum for Kief also falls within these limits, but the five stations, Montpellier, Katharinenburg, Pavlovsk, St. Petersburg, and Cape Horn, show maxima ranging from 1.47 to 1.60, though all except Montpellier are high latitude stations.

If, however, we reduce the maximum rates of Table 10 to mean solar distance, the apparent excess in the rates for the summer at Cape Horn over the rates for the summer at Washington and other northern stations employing Ångström instruments will disappear. Schuster[37] has shown that on a clear day, such as occurred at Washington on February 15, 1907, nearly all of the depletion experienced by the solar rays in passing through the earth's atmosphere, except that due to absorption by aqueous vapor, may be attributed to scattering by the gas molecules. We would therefore expect that at stations in the Northern Hemisphere of approximately the same elevation above sea level, and below 60° latitude, the maximum radiation recorded with the sun near the summer solstice, on those occasional unusually clear days, would not differ markedly from station to station, provided the instruments are in accord.

The range of air mass at noon will be from 1.0 to about 1.25, which, according to the observations plotted on fig. 1, for the best days would not introduce variations in the radiation in excess of 4 per cent. We are therefore led to conclude that the high rates of radiation recorded at Montpellier, Katharinenburg, Pavlovsk, and St. Petersburg are due to instrumental rather than to atmospheric conditions.

Since the original multiple secondary standard of pyrheliometry employed by the Smithsonian Institution was based upon the indications of

[36] See, in the appended Bibliography, references under II. (f). Solar radiation observations, for sources of the data in Table 10.

[37] Molecular scattering and atmospheric absorption. Nature, July 22, 1909, Vol. 81, p. 97.

a pyrheliometer obtained through Crova,[38] it is fair to assume that the standard employed at Montpellier previous to 1900, like this Smithsonian standard, read about 11 per cent higher than the Ångström.

From a discussion of the monthly averages of radiation intensity for Katharinenburg, Pavlovsk and St. Petersburg, Gorczynski[39] was led to the conclusion that the data were not expressed in absolute units.

In this connection, however, it should be remembered that the Chwolson actinometer, with which the records were obtained, is exposed to a very considerable portion of the sky as well as to the sun; and from what has already been said it is easily conceivable that the data do not accurately represent the intensity of solar radiation, but include also a considerable amount of diffuse sky radiation.

ACTUAL MONTHLY RATES OF RADIATION.

While, as has been stated, it is not believed that we yet have sufficient data to accurately compute the amount of radiation actually received on a horizontal surface, it will be of interest to compare determinations made by Gorczynski[40] for Warsaw, and by Westman[41] for Stockholm, with approximate determinations for Washington. For this purpose the monthly totals of column 9, Table 7, have been multiplied by the average duration of sunshine for each month, expressed as fractional parts of the possible totals, which are expressed as percentages in column 10. The results are given in Table 11, and show a rather close agreement between the 3 stations for May, June, and July, which we would expect, since there is little difference between the daily amounts of radiation that may be received at latitudes between 40° and 60° north at the time of the summer solstice[42], provided the atmospheric transmission is everywhere the same.

The computations for Stockholm were based upon records of the duration of sunshine made with the Campbell-Stokes sunshine recorder between July 1, 1904, and December 31, 1906, and measurements of the intensity of solar radiation obtained at Upsala in 1901. The average percentage of possible sunshine recorded at Stockholm appears to have been about 61 per cent in June and 58 per cent in July.

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[38] Annals of the Astrophysical Observatory of the Smithsonian Institution, Vol. 2 p. 39.

[39] Sur la marche annuelle de l'intensité du rayonnement solaire à Varsovie et sur la théorie des appareils employés. Varsovie. 1906. p. 162-164.

[40] Ibid. p. 174-180.

[41] Durée et grandeur de l'insolation à Stockholm par J. Westman. Kungl. Svenska Vetenskapsakadamiens. Handlingar, Band 42, No. 6.

[42] See diagram in W. M. Davis: Elementary Meteorology, p. 21. Boston. 1894.

The duration of sunshine at Warsaw was determined from records made by a photographic sunshine recorder in 1903, and by a Campbell recorder in 1904 and 1905, and was 35 per cent of the possible in 1903, 50 per cent in 1904, and 44 per cent in 1905. The marked deficiency in the quantity of solar radiation in 1903, which will be further considered later, diminished considerably the monthly amounts for Warsaw given in Table 11. For the year 1905 the totals for Warsaw for May, June, and July, after allowing for the recorded duration of sunshine, were 10,010, 9,610, and 10,380, respectively.

TABLE 11.—*Average monthly totals of radiation.*

Stations.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Period.
Per square centimeter of *normal* surface, with a cloudless sky.													
Washington........	16058	18516	21877	23088	25532	25242	26285	24047	21993	19220	16581	15587	1905–1910
Warsaw............	9000	13000	18900	22200	25300	24800	26100	22900	19200	15900	10100	8800	1901–1905
Per square centimeter of *horizontal* surface, with a cloudless sky.													
Washington........	5980	8187	11991	14661	17075	17205	17596	15134	12684	9532	6618	5462	1905–1910
Warsaw............	2100	4100	8400	12000	15300	15700	16100	13200	9400	6100	2700	1700	1901–1905
Per square centimeter of *horizontal* surface, with *record duration* of sunshine.													
Washington........	2709	4437	6008	8577	10006	10684	11191	9247	8092	5824	3594	2862	......
Warsaw............	470	760	2307	3703	8243	8377	9097	7210	4793	1840	383	163	1903–1905
Stockholm........	378	796	2592	5934	9699	12078	11132	7184	4108	1534	312	104	......

COMPUTATION OF THE SOLAR CONSTANT.

In Vol. 1, p. 207–231, of this Bulletin, the author developed a method that was first suggested by Ångström for computing the solar constant from pyrheliometric observations.

Briefly, from determinations of atmospheric transmissibility made by Abbot and Fowle at Washington and on Mount Wilson[43] was derived the equation

$$y_x{}^m = 0.93^{m\delta} x^{m\delta^{1/2}} \tag{34}$$

where x represents the deviation in a spectrum of constant intensity, y the atmospheric transmission coefficient corresponding to this deviation x, m the air mass, and δ the density of the atmospheric diffusing layer, according to Ångström's definition.

The final equation for determining the value of the solar constant, Q_0, is in the form

[43] Annals of the Astrophysical Observatory of the Smithsonian Institution. Vol. 2, p. 111 and 113.

$$Q_0 = \frac{Q_m}{\dfrac{0.93^{m\delta}}{1+0.18m\delta^{1/4}} - (0.061-0.008\delta+0.0012E_0m)} \tag{35}$$

where Q_m is the solar radiation intensity with the sun shining through an air mass m, and $E_0=2.3\ e_0=$ the depth in millimeters to which the earth's surface would be covered with water if all the aqueous vapor were precipitated, e_0 representing the vapor pressure at sea level in millimeters.

The value of δ is determined from the equation

$$\frac{Q_{m+1}}{Q_m} = \frac{\dfrac{0.93^{\delta(m+1)}}{1+0.18(m+1)\delta^{1/4}} - \left[0.061-0.008\delta+0.0012E_0(m+1)\right]}{\dfrac{0.93^{\delta m}}{1+0.18m\delta^{1/4}} - \left[0.061-0.008\delta+0.0012E_0m\right]} \tag{36}$$

If we let $m=2$ the computation of the value of the solar constant is made very simple by the preparation of two tables, from the first of which, entering with e_0 and the ratio $\frac{Q_3}{Q_2}$ as arguments, we obtain δ, and entering the second with δ and e_0 as arguments we determine what part Q_2 is of Q_0.

In developing the above formulas certain assumptions have been made which will now be considered.

1. The form of the normal spectrum energy curve outside the atmosphere is accurately known, and does not vary.

As a matter of fact Abbot and Fowle[44] have already shown that the curve published by them in Vol. 2 of the Annals, and reproduced in fig. 2, *a, a,* herewith, which has been here employed, is inexact, and, further, that especially at the violet end the form may vary from time to time, but that this variation will not have an important effect on the relative values of solar constant determinations.

2. The general atmospheric absorption follows the law expressed in equation (34) without showing marked selective absorption for different wave lengths from time to time. The curves *b, b,* and *c, c,* in fig. 2, indicate observed atmospheric transmission coefficients for Washington, and *c′, c′,* the corresponding coefficients computed by means of equation (34), while *d, d,* are the observed, and *d′, d′,* the computed coefficients for Mount Wilson. An investigation published in Vol. 1, p. 223 and 224 of this Bulletin, indicates unimportant selective absorption over considerable regions of the spectrum on certain days.

[44] Astrophysical Journal, 1909, Vol. 29, p. 281.

3. The atmospheric conditions remain constant during the time required to determine the ratio $\frac{Q_{m+1}}{Q_m}$.

This assumption is, in general, far from the truth, and we will consider three possible sources of error.

A. There may be a change in atmospheric mass due to barometric fluctuations. However, under conditions such as allow good pyrheliometric observations to be obtained, the changes of this character are always small, and may be disregarded.

B. There may be a change in the aqueous vapor content of the atmosphere, or the diurnal variation in the vapor pressure at the surface, e_0, may lead to erroneous determinations of the vapor content, E.

Any marked change in the vapor content of the upper layers of the atmosphere would undoubtedly produce clouding, and interrupt the pyrheliometric observations. But in summer, e_0 passes through a maximum value at about 8 a. m. and through a minimum value at about 4 p. m., at which times $m=2$, the departures from the normal value of e_0 amounting to $+1$ mm. and -1 mm., respectively. If from this cause e_0 should introduce an error of 20 per cent in E_0 the resulting error in Q_0 would be 1 per cent. This is a possible error.

C. The general atmospheric transmission may change during the time required to determine the ratio $\frac{Q_3}{Q_2}$.

This is a very common occurrence. The haziness of the atmosphere may increase, or slowly diminish, in either case modifying the value of the ratio $\frac{Q_3}{Q_2}$ and the resulting value of δ. Changes of this character are often so gradual as to be difficult to detect in the pyrheliometric observations. In previous papers[45] the author has referred to an apparent relation between the percentage of polarization of skylight and the transmissibility of the atmosphere for solar radiation. An effort has therefore been made to express this relation as a function of the density of the atmospheric diffusing layers, δ,[46] which has thus far been only partially successful. However, better results have been derived from a study of the diurnal variation of sky polarization.

Representing by P_m the percentage of polarization of sky light with the sun shining through air mass m, and by P_1 the corresponding polari-

[45] Monthly Weather Review, 1903, Vol. 31, p. 332; Proc. Third Convention of W. B. Officials, Peoria, Ill., 1904, p. 71.

[46] See this Bulletin, Vol. 2, p. 55 and 214.

zation with the sun in the zenith, the diurnal variation in sky polarization is expressed by the equation[47]

$$a_x{}^m = \frac{P_m}{P_1}. \tag{37}$$

It remains to determine the effect of variations in the value of a_x upon the computed value of the solar constant.

TABLE 12.—*Solar constant determinations on days having an average value of a_x.*

Date.	P_2.	a_x.	e_0.	Q_3/Q_2.	Q_2.	δ.	Q_0.	Relative weight.
1905.								
December 22, p. m.	67.0	1.013	4.17	0.841	1.302	0.514	1.979	4
December 26, p. m.	68.4	1.008	2.87	0.845	1.290	0.540	1.960	5
1906.								
February 15, p. m.	67.2	1.013	2.16	0.853	1.390	0.510	2.075	6
April 2, p. m.	66.1	1.005	2.62	0.829	1.311	0.660	2.071	6
April 18, a. m.	53.9	1.009	4.80	0.739	1.076	1.315	2.100	5
May 29, p. m.	65.1	1.008	9.90	0.821	1.288	0.440	2.000	7
November 1, p. m.	71.6	1.007	3.20	0.844	1.404	0.530	2.131	5
November 2, a. m.	71.0	1.014	3.45	0.870	1.384	0.355	1.966	4
November 2, p. m.	70.1	1.011	3.68	0.858	1.360	0.420	1.991	8
November 3, p. m.	71.0	1.006	3.33	0.857	1.412	0.440	2.076	8
November 6, a. m.	66.4	1.009	4.95	0.822	1.338	0.620	2.129	5
November 6, p. m.	68.4	1.012	3.68	0.839	1.380	0.545	2.113	8
November 7, p. m.	67.6	1.009	3.02	0.842	1.359	0.550	2.075	6
November 22, p. m.	71.5	1.009	4.95	0.879	1.403	0.265	1.942	6
Mean							2.056	
1907.								
January 21, p. m.	69.2	1.012	1.75	0.863	1.373	0.455	2.004	5
January 23, p. m.	67.8	1.016	0.99	0.857	1.411	0.530	2.101	4
March 15, p. m.	60.8	1.009	3.38	0.820	1.243	0.710	2.008	2
March 20, p. m.	66.8	1.014	3.62	0.854	1.320	0.450	1.953	3
May 13, p. m.	55.3	1.014	6.76	0.758	1.115	1.000	2.035	10
October 8, p. m.	62.4	1.012	6.27	0.838	1.314	0.460	1.997	3
Mean							2.016	
1908.								
January 14, p. m.	57.2	1.003	2.49	0.839	1.311	0.590	2.018	3
January 30, a. m.	62.0	1.000	1.02	0.856	1.334	0.535	1.994	8
July 16, a. m.	66.6	0.997	10.59	0.834	1.341	0.345	2.010	3
October 3, a. m.	64.9	1.010	6.76	0.851	1.332	0.370	1.960	2
October 12, p. m.	66.5	1.012	3.63	0.863	1.276	0.385	2.033	8
November 12, p. m.	63.2	1.007	2.24	0.821	1.231	0.750	1.992	4
Mean							2.001	
1909.								
February 11, p. m.	64.8	1.009	1.38	0.879	1.388	0.360	1.947	2
May 4, a. m.	62.0	1.005	4.75	0.828	1.292	0.580	2.022	4
July 19, a. m.	66.5	1.013	7.57	0.856	1.342	0.310	1.934	2
September 30, p. m.	67.7	1.011	5.56	0.843	1.318	0.452	1.982	4
October 1, p. m.	59.2	1.014	6.76	0.774	1.136	0.875	1.996	6
October 19, p. m.	68.2	1.012	3.30	0.863	1.385	0.400	2.004	6
October 22, p. m.	65.8	1.012	3.99	0.837	1.317	0.545	2.023	5
November 26, p. m.	65.1	1.012	4.95	0.826	1.275	0.585	2.002	2
December 1, p. m.	70.2	1.011	1.25	0.869	1.400	0.430	2.017	5
December 9, p. m.	66.9	1.011	1.60	0.878	1.389	0.370	1.959	2
December 23, a. m.	62.1	1.014	2.74	0.806	1.205	0.865	2.029	3
Mean							1.992	
1910.								
January 10, p. m.	66.7	1.013	1.60	0.858	1.389	0.495	2.052	2
January 19, p. m.	69.2	0.998	2.49	0.863	1.332	0.430	1.939	2
February 25, p. m.	65.3	1.017	1.45	0.840	1.304	0.630	2.019	6
Mean (1905–1910)							2.016	

[47] See this Bulletin, Vol. 2, p. 60.

In Table 12 are given the results of computations of the value of the solar constant by means of equation (35) on days when the value of a_x did not depart from its mean value of 1.007 by more than 1 per cent, and when the relative weight given the plotted pyrheliometric observations was greater than 1 on a scale of 10, the highest weight being given to observations covering both a morning and an afternoon period that plotted practically on the same curve.

TABLE 13.—*Solar constant determinations on days with a high value of a_x.*

Date.	P_2.	a_x.	e_0.	Q_3/Q_2.	Q_2.	δ.	Q_0.	Relative weight.
1906.								
January 9, p. m.*	55.0	1.055	1.96	0.817	1.374	0.785	2.249	3
January 10 p. m.*	58.5	1.043	1.32	0.872	1.352	0.415	1.940	4
February 13, p. m.	65.9	1.034	4.17	0.859	1.340	0.400	1.953	6
March 22, p. m.*	57.0	1.055	1.78	0.829	1.223	0.710	1.947	6
April 17, a. m	51.6	1.033	4.57	0.766	1.090	1.080	1.989	9
April 17, p. m	51.0	1.021	4.44	0.760	1.071	1.150	1.994	9
May 18, p. m	42.5	1.041	8.50	0.696	0.882	1.395	1.838	3
October 15, p. m	63.6	1.020	7.06	0.819	1.266	0.555	2.006	4
November 3, a. m	70.3	1.030	4.57	0.876	1.410	0.290	1.966	4
1907.								
February 15, p. m.*	64.0	1.044	1.45	0.873	1.406	0.400	2.006	5
March 2, p. m	64.5	1.040	4.44	0.883	1.316	0.255	1.920	2
March 25, p. m	65.2	1.021	4.50	0.852	1.326	0.440	1.970	2
April 2, a. m	67.4	1.021	2.36	0.867	1.417	0.410	2.039	8
April 2, p. m	63.8	1.021	1.80	0.840	1.348	0.620	2.083	4
April 25, a. m	43.4	1.030	6.76	0.739	0.980	1.175	1.881	2
1908.								
January 9, p. m	51.4	1.037	1.45	0.853	1.231	0.535	1.843	2
February 6, p. m.*	45.0	1.092	3.30	0.787	1.131	0.965	1.970	3
February 8, p. m.*	46.1	1.090	1.52	0.836	1.341	0.670	2.102	4
June 16, p. m	61.1	1.021	7.87	0.832	1.274	0.450	1.948	2
August 2, p. m	57.2	1.019	10.08	0.751	1.095	0.870	1.981	2
September 16, a. m	63.1	1.040	7.57	0.855	1.311	0.320	1.897	2
November 12, a. m	67.2	1.043	2.74	0.876	1.395	0.340	1.950	2
1909.								
May 12, a. m	60.8	1.023	3.81	0.859	1.321	0.425	1.940	2
September 25, a. m	70.0	1.022	6.27	0.871	1.406	0.272	1.972	2
September 29, p. m	64.6	1.019	5.79	0.791	1.212	0.790	2.054	3
November 17, p. m	61.6	1.019	4.75	0.834	1.281	0.542	1.980	2
November 26, a. m	66.3	1.019	3.99	0.828	1.266	0.620	1.994	6
1910.								
January 10, a. m	67.5	1.021	1.45	0.886	1.427	0.312	1.971	4
February 1, p. m.*	46.7	1.082	2.16	0.753	1.041	1.380	2.010	2
February 7, p. m.*	63.1	1.064	0.97	0.871	1.375	0.430	1.978	3
February 25, a. m	62.4	1.019	1.02	0.818	1.237	0.840	2.038	4
March 7, a. m	65.6	1.047	2.37	0.857	1.351	0.475	1.996	6
Mean	....	....	....	....	....	....	1.981	....

*Snow on ground

The values of Q_2 have been reduced to mean solar distance and to the Smithsonian provisional multiple pyrheliometric scale, this latter reduction being for the purpose of obtaining a comparison with the values of the solar constant computed at the Astrophysical Observatory of the Smithsonian Institution, although as already indicated[48] the standard employed in those determinations was probably about 5 per

[48] See footnote No. 29.

cent too high. The values of Q_0 here given can therefore be considered as relative only.

P_2 is the percentage of polarization of skylight as determined with the sun 60° from the zenith.

TABLE 14.—*Solar constant determinations on days with a low value of a_x.*

Date.	P_2.	a_x.	e_0.	Q_3/Q_2.	Q_2.	δ.	Q_0.	Relative weight.
1906.								
January 29, p. m.	68.6	0.993	3.30	0.816	1.324	0.735	2.153	3
May 29, a. m.	66.1	0.889	6.50	0.794	1.252	0.750	2.104	9
November 27, p. m.	67.1	0.991	4.57	0.807	1.298	0.750	2.145	3
1907.								
May 13, a. m.	53.6	0.993	7.57	0.757	1.095	0.965	1.991	10
July 27, a. m.	52.6	0.917	9.47	0.787	1.184	0.660	1.987	3
October 10, p. m.	52.9	0.975	8.18	0.756	1.045	0.945	1.900	3
October 15, p. m.	54.8	0.994	5.36	0.757	1.038	1.110	1.922	4
1908.								
April 21, p. m.	57.1	0 984	1.96	0.755	1.214	1.370	2.335	5
April 29, p. m.	51.9	0.942	4.75	0.746	1.104	1.250	2.115	3
June 2, a. m.	57.8	0.959	8.18	0.798	1.227	0.650	2.028	3
July 11, p. m.	54.2	0.972	10.97	0.667	0.919	1.430	1.989	3
October 2, p. m.	64.9	0.972	4.14	0.821	1.309	0.670	2.094	4
1909.								
February 6, p. m.	62.5	0.990	3.18	0.873	1.303	0.760	2.136	2
April 26, p. m.	59.0	0.993	4.37	0.769	1.219	1.070	2.212	3
April 28, a. m.	62.2	0.985	3.00	0.835	1.354	0.600	2.102	6
July 4, a. m.	63.5	0.992	7.87	0.830	1.293	0.460	1.986	6
July 8, a. m.	57.6	0.973	9.83	0.783	1.095	0.675	2.022	4
August 11, a. m.	67.0	0.989	8.18	0.833	1.334	0.430	2.034	5
November 30, p. m.	71.5	0.982	1.60	0.866	1.392	0.442	2.023	2
December 1, a. m.	69.2	0.975	1.19	0.853	1.350	0.550	2.030	4
1910.								
March 7, p. m.	62.5	0.992	2.87	0.803	1.283	0.855	2.156	3
Mean	....	....	....	....	....	....	2.070	....

In Tables 13 and 14 are given the values of the solar constant, Q_0, from computations on days when a_x had a value above its average and below its average, respectively. A high value of a_x indicates that the sky was relatively clear when the sun was near the horizon, and a low value that it was relatively clear when the sun was near the zenith. In general, the effect upon the values of Q_0 is as we would expect, as shown by the means of each table. The effect is more pronounced if we disregard in Table 13 the days on which the ground was covered with snow, when the value of a_x is always abnormally high, and in Table 14 the morning observations obtained during June and July, and the afternoon observations of July 11, 1908, and October 10 and 15, 1907. With reference to these three latter days the values of Q_2 show that the atmospheric absorption was unusually great, rendering extrapolation to zero atmosphere correspondingly uncertain; while with reference to the former, there appears to be a tendency for the polarization to be abnormally low during the early morning hours of summer, perhaps as has been suggested by Prof. W. J. Humphreys, on account of the conden-

sation of moisture on the cold dust particles in the atmosphere at that time.

VARIATIONS IN THE VALUE OF THE SOLAR CONSTANT.

Confining our attention to the forty values of Q_0 given in Table 12, it is seen that they vary between a minimum of 1.934 and a maximum of 2.131, or from 4 per cent below to about 6 per cent above their mean value of 2.016.

Furthermore, the mean values for 1906 and for 1909 are, respectively, 2 per cent above and 1 per cent below the general mean.

These results are comparable with those obtained spectrobolometrically by Abbot and Fowle[49] at Washington and on Mount Wilson. The range of solar constant values obtained by them at Washington between October, 1902, and May, 1907, is from 1.863 to 2.379, omitting determinations rated "poor"; while the two series obtained on Mount Wilson between June and October, 1905, and May and October, 1906, give a minimum of 1.93 and a maximum of 2.12. Also, the mean of the values obtained by them at Washington between April, 1903, and January, 1904, is 7 per cent below the average for the years 1902 to 1907, inclusive, and in 1906 it is 4 per cent above this average; while on Mount Wilson, in 1905, the average for the values obtained between June 6 and August 11 is 2.052, and between August 14 and October 26 only 2.003.

Abbot and Fowle are unable to attribute such variations in the value of the solar constant as have been found on Mount Wilson to instrumental errors, to atmospheric changes, or to faulty reduction methods. They therefore accept them as representing actual variations in the intensity of solar radiation at the outer limit of the earth's atmosphere. And while they do not speak with equal confidence with respect to the accuracy of their Washington determinations, yet they regard them as indicative of diminished intensity of solar radiation outside the earth's atmosphere during 1903 and 1904. Furthermore, they have investigated the monthly temperature departures[50] from the normal at inland stations in North America, Europe, northern Asia, southern Asia, and Australia, and find that generally they also were below the average during 1903 and 1904.

Although the same degree of accuracy can not be claimed for pyrheliometric as for spectro-bolometric determinations, yet it is clear that the

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[49] Annals of the Astrophysical Observatory of the Smithsonian Institution, Vol. 2, p. 103.

[50] Ibid., Plate XXV, opposite p. 200.

values given in Table 12 are confirmatory of those obtained on Mount Wilson.

Abbot and Fowle[51] have suggested that a systematic difference of 3.6 per cent that exists between determinations of the value of the solar constant made simultaneously by them on Mount Wilson and at Washington may be due to a lack of steadiness in atmospheric conditions at one of these two places. A study of the relation between the values of Q_0 and a_x given in Tables 12, 13, and 14, herewith, leads to the conclusion that their suggestion is correct; and, further, that the extreme values obtained by them at Washington are probably attributable to this cause. Indeed, observations at Washington on September 19, 1905, show that the polarization increased from 50.6 per cent at 1 p. m. to 61.2 per cent at 3:45 p. m., indicating such an increase in atmospheric transparency as would account for the low value, 1.814, which was obtained by them for the solar constant on that date.

Reference should also be made to Gorczynski's[52] computations by means of equation (35) with new values assigned to the constants in the term in parentheses in the denominator of the second member of the equation. This term takes account of the absorption of solar radiation by the gases in the atmosphere. Gorczynski, as well as Westman,[53] attribute a greater loss from this source than do Abbot and Fowle, or than would appear to be justified by Scheiner's[54] laboratory determinations.

VARIATIONS IN ATMOSPHERIC TRANSMISSIBILITY.

No continuous series of solar constant determinations exists prior to that of the Smithsonian Institution commencing in 1902. A continuous series of pyrheliometric observations made at Montpellier, France, covers the 18 years from 1883 to 1900, inclusive, while several overlapping series cover the period from 1900 to date.

In addition to the changes in solar radiation intensity that are continually occurring from day to day, and which are clearly due to weather conditions, the observations show long periods even of several months duration during which there was a marked deficiency in the amount of solar radiation that reached the surface of the earth. The first of these

[51] Ibid., p. 103.

[52] Sul valore della "Costante Solare". Mem. Soc. spettr. Ital., Catania. v. 39, p 59–66.

[53] Mésures de l'intensité de la radiation solaire faites à Upsala en 1901, p. 26.

[54] Untersuchungen über die Solarkonstante und die Temperatur der Sonnenphotosphäre. Publicationen des Astrophysikalischen Observatoriums zu Potsdam. Nr. 55 18 Bd. 3tes Stück.

periods culminated in 1885, following the great volcanic eruption of Krakatoa in 1883. It is clearly shown in the Crova actinometer records for Montpellier, France,[55] plotted in fig. 3 as curve I, where each ordinate represents the average for the year of the noon values of the actinometer readings, expressed as a percentage of the average noon values for the whole series. The average for 1885 was only 87 per cent of that for the remaining 17 years. This curve also shows a secondary depression, which culminated in 1891.

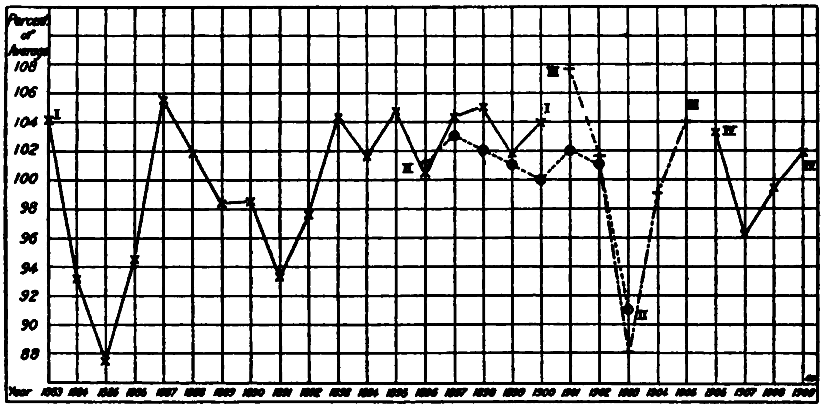

FIG. 3.—Annual averages of solar radiation received at the earth's surface, expressed as percentages of the general average.
I.—Montpellier, at noon.
II.—Lausanne, at noon.
III.—Warsaw, with solar zenith distance of 60°.
IV.—Washington, with solar zenith distance of 60°.

The ordinates of curve II, fig. 3, represent the yearly averages of solar radiation measured at noon by a Crova actinometer at Lausanne, Switzerland,[56] each expressed as percentages of the average for the eight years, 1896 to 1903, inclusive; while curve III represents the annual averages for Warsaw, Poland,[57] reduced to a solar zenith distance of 60° and expressed as percentages of the average for the 5 years, 1901 to 1905, inclusive. These two curves agree in showing a decided depression in 1903, following the great volcanic eruptions of 1902. The average for Lausanne for 1903 as compared with the average for the remaining 7 years of the series is 90 per cent, while the corresponding average for

[55] Bulletin météorologique du Département de l'Hérault, année 1900. p. 136.
[56] Archives des Sciences physiques et naturelles, Series 4, Tome 16, p. 530.
[57] Gorczynski, l. c.

Warsaw as compared with that for the 4 years 1901, 1902, 1904, and 1905 is 86 per cent.

TABLE 15.—*Monthly averages and departures of radiation at the earth's surface at noon, expressed in gram-calories per minute per square centimeter of normal surface.*

Months.	Washington. Average means, 1905–1910.	Washington. Departures. 1903.	Washington. Departures. 1904.	Warsaw. Average means, 1901, '02, '04, '05.	Warsaw. Departures. 1902.	Warsaw. Departures. 1903.	Warsaw. Departures. 1904.	Lausanne. Average means, 1896–1902.	Lausanne. Departures. 1902.	Lausanne. Departures. 1903.	Lausanne. Departures. 1904.	Modena. Maxima. 1902.	Modena. Maxima. 1903.
		Per ct.	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*		
January	1.16	......	......	0.79	+ 5	......	−19	0.79	− 4	−14	−17	1.20	0.91
February	1.28	......	......	0.97	+ 5	−18	−23	0.85	+ 1	−15	− 4	1.00	1.02
March	1.26	......	......	1.15	+ 1	−19	+ 4	0.90	− 1	−19	− 8	1.33	1.12
April	1.26	−17	−12	1.18	± 0	......	− 2	0.91	− 1	−13	− 8	1.28	1.14
May	1.23	−19	− 6	1.22	− 9	−21	+ 2	0.86	− 6	− 8	± 0	1.26	1.12
June	1.20	−18	− 6	1.15	− 2	......	+ 1	0.85	+ 5	− 9	− 2	1.22	1.03
July	1.21	− 9	− 4	1.22	+ 1	−16	− 2	0.86	+ 2	− 7	− 1	1.37	......
August	1.16	......	− 2	1.16	± 0	−15	± 0	0.88	− 1	− 6	− 2	1.28	......
September	1.23	−12	−10	1.19	+ 1	−15	± 0	0.86	− 3	− 9	......	1.32	......
October	1.19	−17	− 6	1.02	− 2	−23	− 3	0.86	− 2	− 7	......	1.19	......
November	1.23	−27	−14	0.89	+ 2	......	......	0.82	+ 4	−12	......	1.04	......
December	1.15	−31	+ 4	0.80	−17	......	......	0.75	−15	−16	......	1.04	......

Month.	Pavlovsk. Average means, 1894–1903.	Pavlovsk. Departures. 1902.	Pavlovsk. Departures. 1903.	Pavlovsk. Departures. 1904.	Pavlovsk. Average maxima, 1893–1906.	Pavlovsk. Departures. 1902.	Pavlovsk. Departures. 1903.	Pavlovsk. Departures. 1904.	St. Petersburg. Average maxima, 1895–1904.	St. Petersburg. Departures. 1902.	St. Petersburg. Departures. 1903.	St. Petersburg. Departures. 1904.
		Per ct.	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*		*Per ct.*	*Per ct.*	*Per ct.*
January	0.90	......	−29	−27	0.96	......	−30	−19	0.76	......	......	......
February	1.04	+ 5	−15	−20	1.16	+ 6	−12	−18	1.02	......	......	−38
March	1.19	+ 6	−10	+ 2	1.35	− 1	−13	+ 2	1.24	+ 6	−25	− 6
April	1.27	+ 5	−18	− 6	1.36	+ 6	−12	− 1	1.24	......	−37	−17
May	1.25	+ 6	− 7	− 2	1.35	+ 2	− 7	− 8	1.30	− 5	−13	−10
June	1.21	+ 6	−14	......	1.30	+ 2	−11	− 2	1.23	+ 1	−20	−11
July	1.16	+ 9	− 3	......	1.27	± 0	− 3	− 2	1.28	......	......	−14
August	1.17	+ 6	− 3	......	1.25	± 0	− 6	− 4	1.22	......	−16	− 9
September	1.16	− 1	− 6	......	1.28	− 4	− 6	− 2	1.13	+ 5	−12	+ 7
October	1.08	± 0	− 7	......	1.17	± 0	− 2	− 3	1.14	......	......	−10
November	0.90	− 1	− 9	......	0.99	− 4	− 4	......	0.86	+ 1	......	−15
December	0.79	......	−35	......	0.81	......	−26	− 12	0.73	−16	......	......

TABLE 15 (*a*).—*Duration of sunshine.*

Place.	Hours of sunshine. 1902.	Hours of sunshine. 1903.	Hours of sunshine. 1904.	Per cent of possible sunshine. 1902.	Per cent of possible sunshine. 1903.	Per cent of possible sunshine. 1904.	Place.	Hours of sunshine. 1902.	Hours of sunshine. 1903.	Hours of sunshine. 1904.	Per cent of possible sunshine. 1902.	Per cent of possible sunshine. 1903.	Per cent of possible sunshine. 1904.
Washington	......	......	......	......	55	55	Modena	......	......	......	46	48	......
Warsaw	......	......	......	......	35	50	Pavlovsk	......	......	......	27	26	29
Lausanne	1596	1708	1792	......	......	......	St. Petersb'g	......	......	......	31	37	39

In obtaining the monthly departures of radiation[58] given in Table 15, the monthly averages have been employed when available. For St. Petersburg it was necessary to compare the monthly maxima for the 3 years, 1902, 1903, and 1904, with the average monthly maxima for the 10 years, 1895 to 1904, inclusive. For Modena the maxima themselves are given, as the series is too short to obtain averages. At Washington the pyrheliometric observations suffered an unfortunate interruption during January, February, and March, 1904, due to a defective ammeter. Furthermore, the averages for 1905 to 1910 are not strictly comparable with data obtained in 1903 and 1904, but this will not account for the departures here shown.

In general, the data of Table 15 for all the stations show that a diminution in the intensity of solar radiation at the surface of the earth set in about December, 1903, and continued until March, 1904, after which there was a gradual return to normal conditions. St. Petersburg, the most northern of these stations, appears to have been the slowest to recover.

The maxima for Hald given in Table 10, which are for the period July, 1902, to June, 1903, also show this depression, as has been brought out in a discussion of the data by Holm.[59] Gorczynski[60] has also discussed this depression in connection with the data for Warsaw and some other places, and Bührer and Dufour[61] have discussed it in connection with the data for Lausanne.

In a previous consideration of this subject by the author,[62] reference was made to a decrease in the polarization of skylight at Washington that accompanied the diminution in radiation intensity, and also to an increase in the distance of the neutral points of Arago and Babinet from the antisolar point and the sun, respectively, observed by Busch and Sachs in Germany. A diagram published by Chr. Jensen[63] shows that these distances were above the normal in 1886—the beginning of the record—

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[58] See "Bibliography: II. (f.) Solar Radiation Observations", for the sources of these data, except average means for 1894 to 1903, inclusive, for Pavlovsk, which were furnished by the Director of the Central Physical Observatory of St. Petersburg, in reply to a circular letter sent out by Prof. Cleveland Abbe on April 15, 1904.

[59] Arkiv för matematik, astronomi, och Fysik, Band 2, No. 4.

[60] Sur la marche annuelle de l'intensité du rayonnement solaire à Varsovie. Varsovie, 1906.

[61] Archives des sciences physiques et naturelles, Series 4, 1905, Tome 19, p. 388.

[62] Proc. Third Convention of Weather Bureau Officials, Peoria, Ill., 1904, p. 69.

[63] Die gegenwärtigen Probleme und Aufgaben welche mit dem Studium der atmosphärischen Polarisation verknupft sind. Abdruck aus den Astr. Nachr. Nr. 4283, Bd. 179. Nov., 1908.

and passed through maxima in 1892–93, and in 1904, the latter being the more pronounced of the two. It will be noted that these maxima are about one year later, respectively, than the minima of solar radiation of 1891 and 1903, shown in fig. 3.

TABLE 16.—*Average monthly maxima and departures of sky polarization with the sun at zenith distance 60°.*

Month.	Averages, 1903-1910.	Departures.							
		1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
January	64	....	−12	− 8	+ 5	+ 5	− 2	± 0	+ 5
February	63	....	−11	−11	+ 4	+ 6	+ 7	+ 5	+ 2
March	61	....	− 8	± 0	− 4	+ 6	......	± 0	+ 5
April	63	....	− 6	....	+ 6	+ 7	− 4	+ 2	− 5
May	57	−13	− 2	....	+ 9	− 2	+ 1	+ 5	......
June	56	−18	+ 3	+ 2	+ 2	....	+ 5	+ 7	......
July	57	− 9	− 1	− 3	....	− 4	+10	+ 9	......
August	58	....	− 6	− 3	....	....	+ 1	+ 9	......
September	62	− 7	− 3	+ 5	− 1	....	+ 1	+ 8	......
October	64	− 9	+ 1	+ 5	± 0	− 1	+ 3	+ 4	......
November	66	− 8	− 8	+ 3	+ 6	....	+ 3	+ 6	......
December	63	−10	− 1	+ 5	....	+ 1	....	+ 7	......

In Table 16 there are given the departures of the monthly maxima of sky polarization at Washington, with the sun at zenith distance 60°, from the monthly averages of these maxima for the 7 years, May, 1903, to April, 1910, inclusive. These departures indicate an increase in atmospheric transmissibility during 1904, and again during the latter part of 1905.

From the data presented it is seen that, while evidence of a diminution in the value of the solar constant in 1903 is confined to a single series of determinations made at the Astrophysical Observatory of the Smithsonian Institution, there is abundant evidence of a widespread diminution in the intensity of solar radiation at the surface of the earth, due in part, at least, to diminished atmospheric transmissibility. That this latter is the case is shown not only by polarization observations, twilight phenomena, halos, coronæ, and other optical phenomena, but also by the atmospheric transmission coefficients determined spectrobolometrically for different wave lengths at the Smithsonian Institution.[64]

Optical phenomena observed in 1885 indicate that the diminution in atmospheric transmissibility was even more marked during that year than during 1903. We must therefore conclude that there have been at least three periods in the last 27 years, namely, in 1885, in 1891, and in 1903, during which the atmosphere was less transparent than usual, and two of these periods followed great volcanic eruptions. Furthermore,

[64] See Annual Reports of the Smithsonian Institution for 1903, 1904, and 1905.

the temperature diagrams of Abbot and Fowle, already referred to, show that the temperature departures between March, 1884, and August, 1885, inclusive, between August, 1890, and August, 1891, inclusive, and between April, 1903, and August, 1904, inclusive, were almost continuously below the normal by amounts averaging 0.20° C. per day for the first period, 0.36° C. per day for the second, and 0.28° C. per day for the third.

Unpublished diagrams prepared by Prof. F. H. Bigelow show that in the United States, and especially east of the one hundred and fifth meridian, the temperature amplitudes, as well as the temperatures themselves, were below the average during the years 1883 to 1886, 1892 to 1893, and 1902 to 1904. It is to be noted that there is not exact synchronism between these three cold periods in the United States and the corresponding periods for the great continental masses, North America, Eurasia, and Australia; that the latter periods are nearly synchronous with the depressions in the curves on fig. 3, and with the maxima of Jensen's curves showing the positions of the neutral points of Arago and Babinet; but that they do not coincide with any special phase of the solar prominence or sun-spot frequency curves published by Bigelow,[65] Wölfer,[66] and others.

It is of interest to note that observations on the visibility of the summit of Mount Etna from the Observatory at Catania,[67] over a distance of about 30 kilometers, show a slight increase in atmospheric transparency in 1903 as compared with the years 1901 and 1902; that photochemical measurements made at the Astronomical Observatory, Kremsmünster,[68] Austria, indicate an unmistakable increase in the intensity of diffuse skylight as compared with that of direct sunlight, beginning with June, 1902, and apparently continuing until after May, 1904, although there was no appreciable increase in the average cloudiness; and that the average duration of sunshine given in Table 15a shows no special decrease in 1903 at any of the stations except Warsaw.

The ordinates of curve IV, fig. 3, represent the annual average intensity of solar radiation at Washington, reduced to 60° zenith distance of the sun, and expressed as a percentage of the average intensity for the 5-year period, May, 1905, to April, 1910, inclusive. This curve agrees with the monthly departures of polarization of Table 16 in showing a

[65] Monthly Weather Review, 1903, Vol. 31, p. 509.

[66] Monthly Weather Review, 1902, Vol. 30, p. 171.

[67] Variazione della transparenza dell'atmosfera, terrestre nel triennio 1901–02–03. (Atti Acc. gioenia. Catania. Luglio 1904. Fasciola 82.)

[68] Letter of the Director of the Observatory, dated May 22, 1904, in reply to a circular sent out by Professor Abbe, on April 15, 1904.

slight depression in 1907; and from the Annual Summary of the Monthly Weather Review we find that this was a cold year in the northern part of the United States and in Canada, but warmer than the average in the southern part of the United States and on the Pacific coast.

It has already been pointed out by the author[69] that any change in the amount of solar radiation received at the surface of the earth must modify the general circulation of the atmosphere, the effects of which it is difficult to predict. In general, however, as has been shown by Professor Bigelow,[70] an increase in surface temperatures in the Tropics would accelerate the circulation, and might thereby lower the temperatures, especially in winter, over regions like the eastern part of North America, where a strong component of motion from the pole towards the equator usually exists. On the other hand lower temperatures in the Tropics might be accompanied by high temperatures over this same region, due to a retardation in the general circulation.

Complete synchronism, therefore, can not be expected between periods of excess or deficiency of temperature in different regions.

Having established the fact that marked variations in the intensity of solar radiation at the surface of the earth do exist, it at once becomes apparent that observations of atmospheric transmissibility and of the intensity of solar radiation should be maintained in all parts of the world, and especially in regions with a high percentage of duration of sunshine.

At a few stations, preferably at high altitudes and in low latitudes, but at any event in regions as free as possible from atmospheric dust and moisture, the value of the solar constant should be determined as frequently as weather conditions will permit. In this way we should be able to ascertain the relation that undoubtedly exists between the variations in the intensity of solar radiation, in the transmissibility of the atmosphere, and in the temperature of its lower strata.

CONCLUSIONS.

1. It is of the utmost importance that the pyrheliometers employed in measuring solar radiation intensities be frequently compared with a substandard, and that an international standard be maintained for the intercomparison of the substandards of the different meteorological services and central observatories.

2. The maximum observed intensity of solar radiation at Washington at the ground,[71] 1.44 calories per minute per square centimeter of normal

[69] Proc. Third Convention U. S. Weather Bureau Officials, Peoria, Ill., 1904, p. 69.

[70] Popular Science Monthly, Vol. 77, p. 461.

[71] i. e., The roof of the Central Office of the U. S. Weather Bureau, about 120 feet above sea level and 40 feet above the ground.—EDITOR.

surface, occurred in April, and the maximum for December, 1.32 calories, is only 8 per cent less. The greatest monthly noon average, 1.28, was obtained in February, and the December average, 1.15, is only 10 per cent less. The greatest daily total of radiation received on a normal surface, 971 calories, was obtained in July, the corresponding December total being 60 per cent as great. The greatest daily total for a horizontal surface, 653 calories, was also obtained in July, and the corresponding total for December is only 30 per cent as great.

3. The totals recorded by a Callendar horizontal pyrheliometer are very considerably in excess of the totals obtained from the Ångström, the differences varying with the atmospheric conditions.

4. Variations in the percentage of sky polarization aside from the diurnal variation are closely related to changes in the general atmospheric absorption.

5. A modified form of the equation suggested by Ångström enables us to compute the value of the solar constant from pyrheliometric determinations of the radiation and psychrometric determinations of the aqueous vapor content of the atmosphere, with a probable error of less than 3 per cent, provided we confine ourselves to observations obtained on cloudless days on which the polarization observations indicate that the atmospheric transmissibility was not changing.

6. There is evidence that the so-called solar constant is a variable quantity.

7. There is stronger evidence that the atmospheric transmissibility undergoes marked changes that are nearly synchronous over considerable portions of at least a hemisphere, and that diminished transmissibility is accompanied by a diminution in temperatures and in temperature amplitudes.

8. Marked diminutions in atmospheric transmissibility occurred in 1884 to 1886, and in 1903 to 1904, that were undoubtedly connected with violent volcanic eruptions. Less marked diminutions in transmissibility occurred in 1891 and 1907 that have not yet been connected with phenomena of this nature.

9. These fluctuations do not coincide with variations in sunspot numbers or in solar prominence frequency.

10. Cooperation between the different meteorological services and astrophysical observatories along lines proposed by the International Meteorological Committee and the International Union for Cooperation in Solar Research will be necessary for a satisfactory solution of some of the problems here presented.

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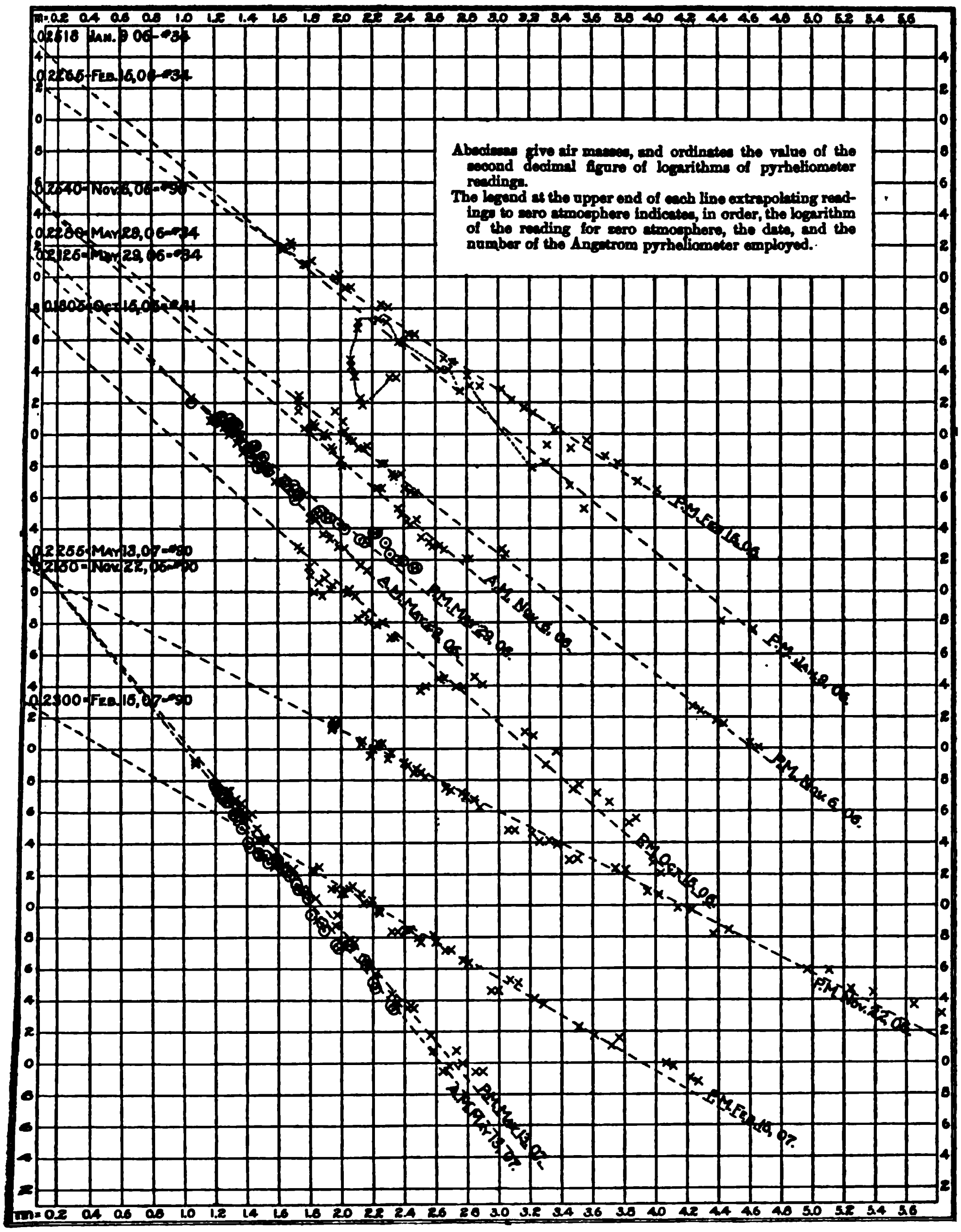

Fig. 1.—Pyrheliometer observations.

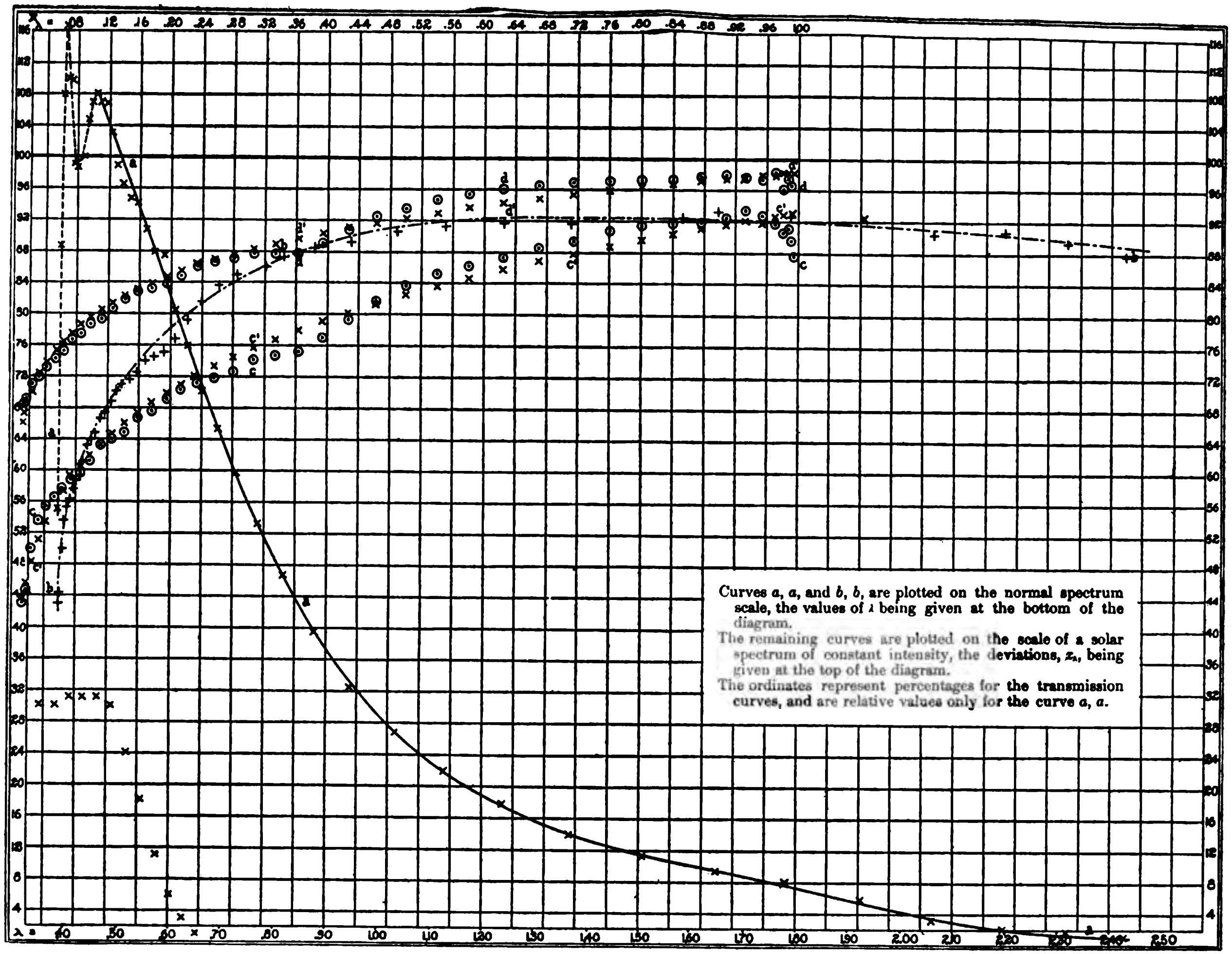

FIG. 2.—Atmospheric transmissibility and normal solar spectrum energy curves.

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U. S. DEPARTMENT OF AGRICULTURE

BULLETIN

OF THE

MOUNT WEATHER OBSERVATORY

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BULLETIN

OF THE

MOUNT WEATHER OBSERVATORY.

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(IV) FREE BALLOON ASCENSIONS AT OMAHA AND INDIANAPOLIS, SEPTEMBER 25 TO OCTOBER 12, 1909.

By the Aerial Section—Wm. R. Blair, in charge.

In most ascensions of the series made at Omaha, rubber balloons capable of expanding to 4½ meters diameter were used. A few ascensions were made, near the end of the series, in which smaller balloons were sent up in pairs. When single balloons were used the meteorograph was attached to a parachute thrown over the balloon. When two balloons were used the balloons and meteorograph were arranged as shown in fig. 1. This arrangement does not subject the instrument to serious vibration, as does the arrangement of the balloons in tandem. The cords *a a′* are of such length that the burst balloon will not interfere with the instrument, and *b* is just long enough to allow the expansion of the balloons without too much strain at their necks. The hydrogen was produced electrolytically. The entire load, including balloon, parachute, and meteorograph, was approximately 3 kg. Each balloon was given an ascensional force of about 1 kg. This required that it be filled to a volume of about 4 cu. m., or until its circumference was slightly over 6 meters.

At Indianapolis balloons of the same sort were used, but the gas was generated chemically and did not have as much lifting power as that used at Omaha. It was therefore necessary to use the balloons in pairs.

Twelve of the thirteen instruments sent up at Fort Omaha, and six of the seven sent up at Indianapolis, were returned. One of the latter failed to furnish an interpretable record.

The mean of the highest altitudes reached in the twelve ascensions at Omaha is 13⅓ km., the highest ascension being 24120 m. A similar mean for the five ascensions at Indianapolis is 14⅗ km., the highest ascension being 19443 m.

The meteorographs used in the ascensions were made by Bosch, and carry two bimetallic thermometers in addition to a hair hygrometer and a Bourdon tube barometer.

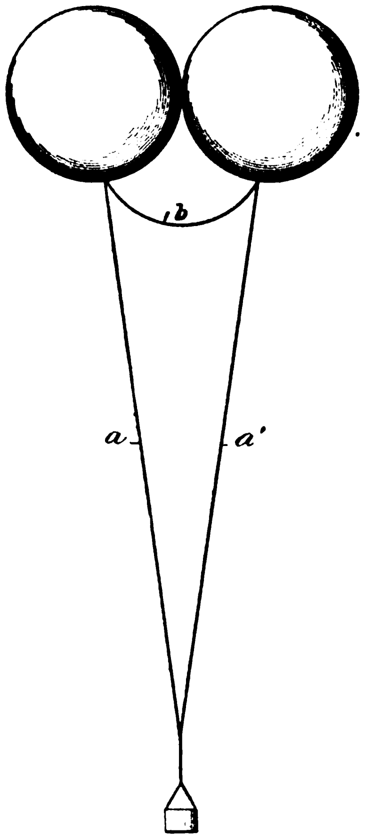

Fig. 1.

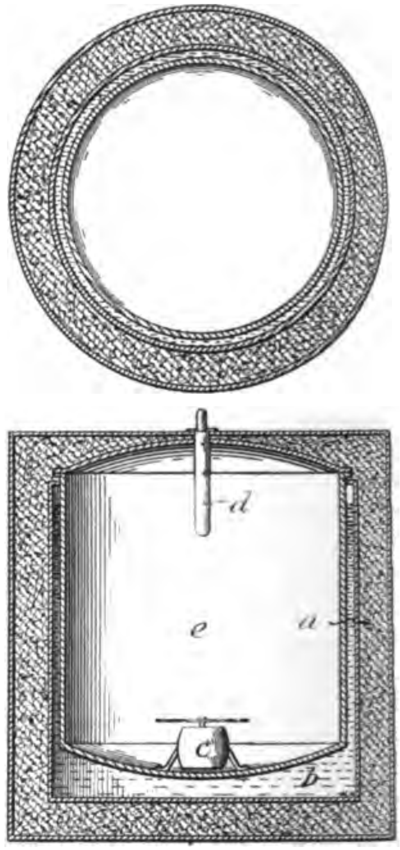

Fig. 2.
a. Packing of hair felt.
b. Cooling solution.
c. Fan motor and fan.
d. Thermometer.
e. Position of temperature elements.

The barometer and thermometers were calibrated simultaneously, the former to 10 cm. or lower; the latter to $-50°$ or lower. These tests were made in a temporary apparatus, a part of which is shown in fig. 2. The inside vessel of copper was air tight and large enough to accommodate four meteorographs. Connection was made with a Geryk pump for evacuating, and with a manometer for determining inside pressures.

A platinum resistance thermometer introduced through the lid of the chamber and electrically connected to a Whipple register served for the reading of inside temperatures. The air in the vessel was stirred by means of an electrically driven fan placed on the bottom, as shown. This air-tight chamber was contained in a second vessel, of 5 cm.greater diameter. The space between the walls was filled with gasoline, and a device was provided for stirring the gasoline. About the second vessel was a third, the space between being filled with a packing of hair felt. Just above the surface of the gasoline the nozzle from a tube containing carbon dioxid was introduced. The solid carbon dioxid fell into the gasoline and cooled it.

There were thirty instruments to be tested, i. e., eight sets.

The supply of carbon dioxid being limited, it was not possible to bring the gasoline to room temperatures before each set. The temperature elements were therefore compared at room temperatures and again at temperatures of $-20°$ to $-50°$. A curve plotted for each element throughout the range of the test enables the computer to interpolate or extrapolate the temperatures or pressures at the desired points on the records furnished by the meteorographs. While these calibrations were not all that could be desired, they were consistently good and probably the best that could be made with the equipment at hand. Apparatus for making more thorough calibrations of these two elements is in process of construction.

The hygrograph was checked at three points only. The instruments were put into a fairly close chamber, in one side of which was a window. For one point, the bottom of the chamber was covered with calcium chlorid; for another, the bottom and top were lined with wet blotting paper; for the third, comparison was made at room humidity. In every case the standard was an Assmann aspiration psychrometer, which also served to stir the air in the chamber. In the determination of any point, the instruments were allowed to record until the conditions about them had become constant, as shown by the trace and also by readings of the standard instrument. The relative humidities at the lower and upper points checked were about 20 per cent and 90 per cent, respectively, the room humidity being about halfway between these.

An area of high pressure was central in eastern Kansas on the morning of September 24. On the evening of the 24th, the highest pressure was in Upper Michigan, where it remained until the evening of the 26th. It returned during the 27th to eastern Kansas. The maximum pressure (780.3 mm.) of the area occurred September 26, a. m. By the evening of the 28th, this area had two centers, one over the Lakes, the other in

southeastern Texas. These centers did not move far from these respective positions until October 6, in the evening of which day there was but one center for the high pressure area, and that was over West Virginia. This new center did not change position until October 9. By the evening of the 10th it had moved off the coast of Newfoundland. A second area of high pressure, central over northern Nevada on the morning of October 10, moved slowly eastward, forming a ridge of pressure from Swift Current to Wichita on the morning of the 12th. By the afternoon of the 12th this had begun to center at Little Rock, and on the 13th was central at Birmingham.

An area of low pressure, central off Puget Sound on the morning of September 24, moved slowly across the country, keeping close to the northern boundary. It passed off the coast of Newfoundland on October 3. The pressure at the center, 750.3 mm., was lowest on the evening of October 1, at the mouth of the St. Lawrence River.

Another low pressure area, central at Edmonton on the afternoon of October 5, reached eastern Kansas on the 8th. It had moved from there to the Lakes by the evening of the 10th. It remained over the Lakes until the 13th, reaching its lowest pressure, 739.6 mm., on the forenoon of the 12th.

Other areas of high and of low pressure appeared during the series, but they were not presistent enough to travel across the continent, and had little, if any, influence at either of the points where ascensions were being made. Probably the first described high pressure area, the second low, and the second high, were in turn the only disturbances influencing conditions at either station during the series.

The data follow in tabular form. In the process of studying these data, plots have been made; figs. 3 and 4 showing the temperature gradient, figs. 5 and 6 the free air isotherms 5° apart, and figs. 7 and 8 the wind directions as observed at Omaha and Indianapolis,respectively. In figs. 3 and 4, solid lines indicate the gradient as observed in the ascent, dashes in the descent. Dot and dash lines have been used, fig. 3, October 6, to represent the second ascension made by the balloon on that day. Long dashes have been used for interpolated temperatures, fig. 3, October 4, and figs. 5 and 6.

The temperature observations seem to be good unless it be true that, at the top of some of the ascensions made with two balloons, the system drifted without a sufficiently rapid change of altitude to properly ventilate the temperature element, e. g., October 5 at Indianapolis and October 12 at Omaha. The base of the upper inversion layer was entered at altitudes varying from 7300 to 15600 meters above sea level.

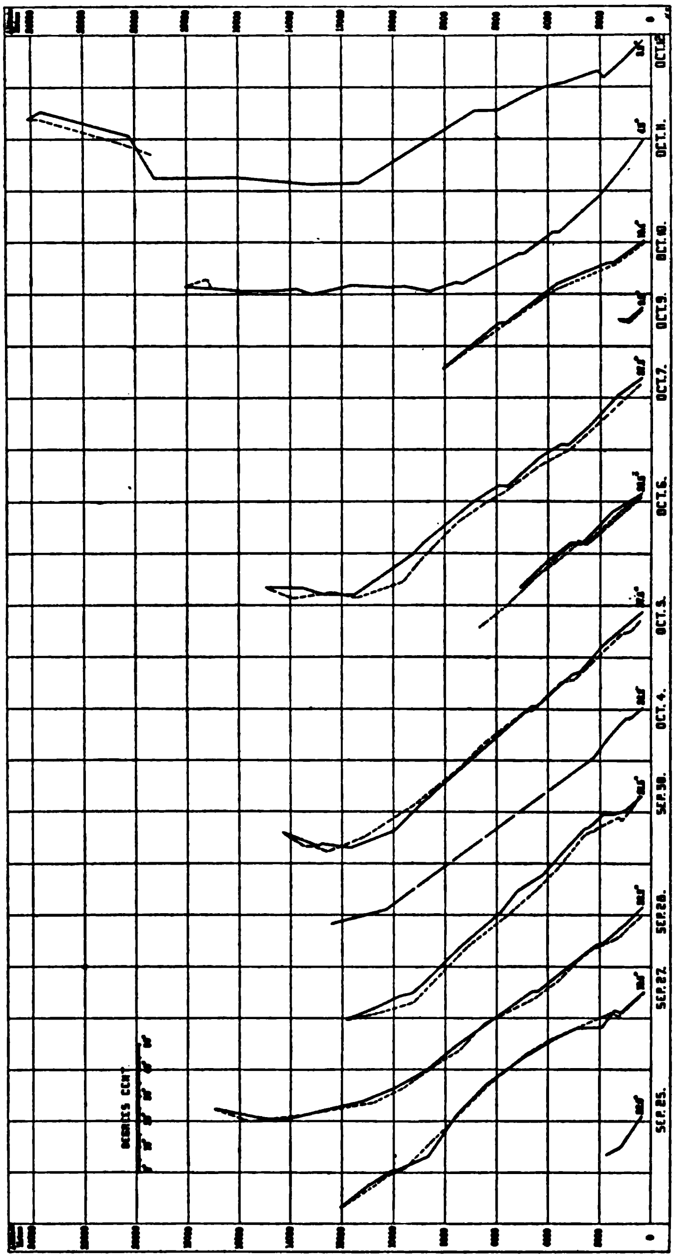

FIG. 3.—Temperature gradient as observed at Omaha, September 25 to October 12, 1909.

The lowest temperatures observed varied from −50 to −65. These extremes were observed on consecutive days. While figs. 5 and 6 contain, of necessity, considerable interpolation, they are of interest in showing the temperature changes from day to day at all altitudes, and the general course of the isotherms in the region of the upper inversion. It appears from the observations charted that the temperature changes from day to day in the region of the upper inversion are usually greater than at lower levels. Figs. 7 and 8 are plots of the horizontal projections of the

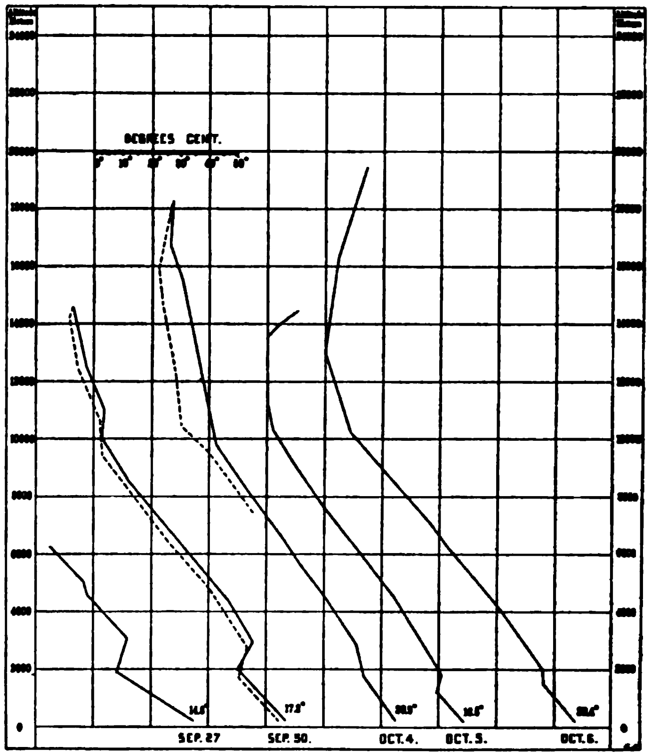

FIG. 4.—Temperature gradient as observed at Indianapolis, September 27 to October 6, 1909.

paths of the balloons to such altitudes and distances as they could be followed with the theodolite. At the outer end of each path is marked the date of the ascension and the altitude of the meteorograph when it became invisible. Wherever the highest point reached in any ascension is projected, its altitude is marked. Other altitudes are marked on the ascensions of October 5 and 6 at Omaha, showing abrupt wind changes

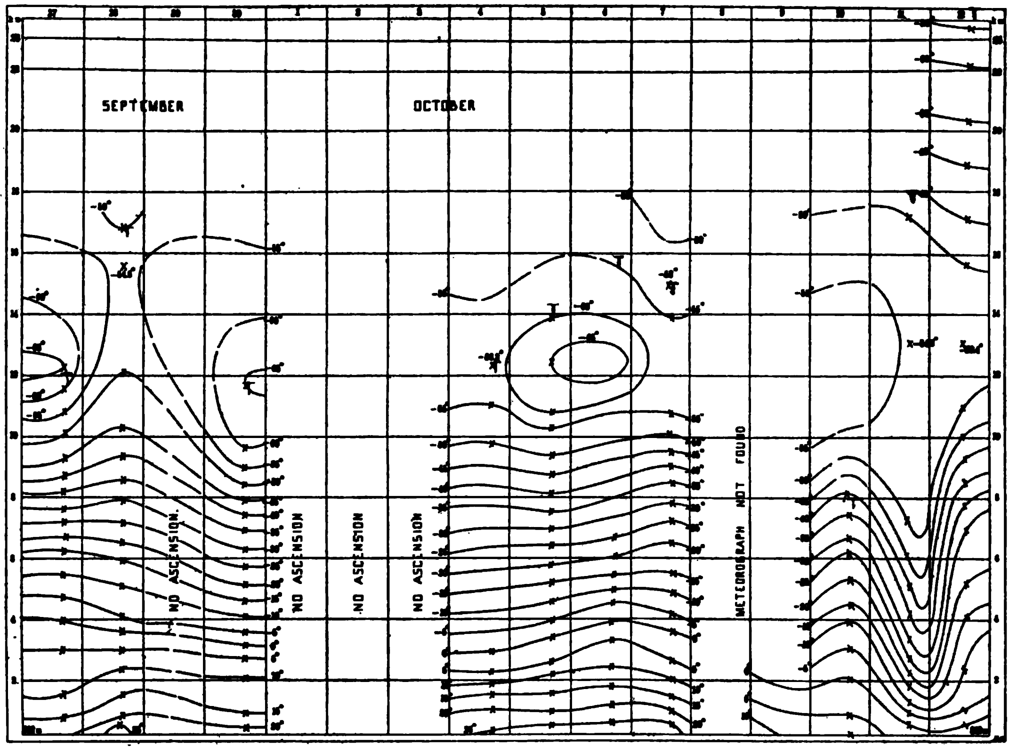

Fig. 5.—Free air isotherms over Omaha, September 27 to October 12, 1909.

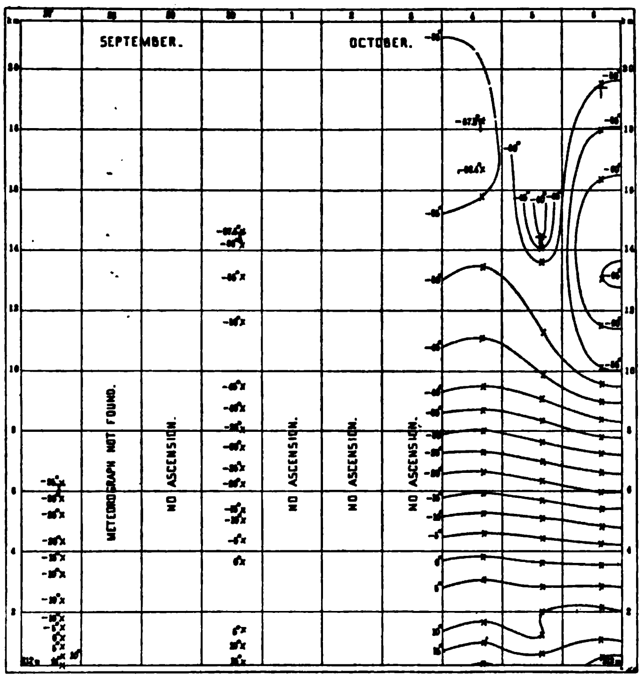

Fig. 6.—Free air isotherms over Indianapolis, September 27 to October 6, 1909

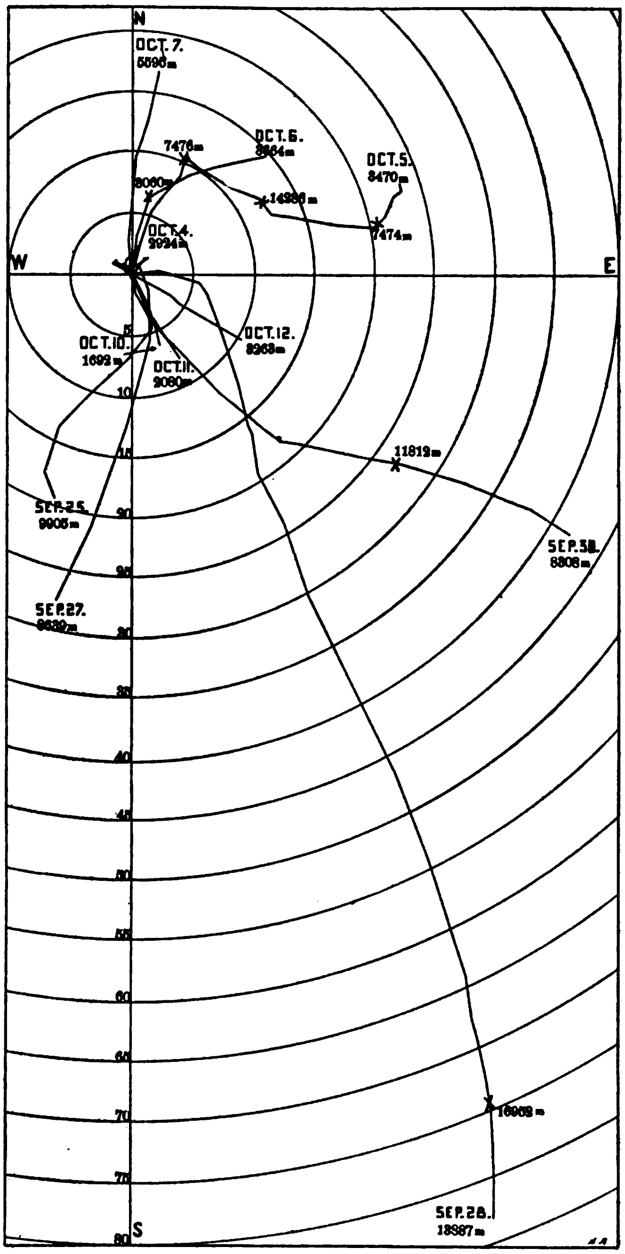

FIG. 7.—Horizontal projections of the paths of the balloons set free at Omaha, September 25 to October 12, 1909.

with altitude. Readings of the elevation and azimuth of the balloon were taken at the end of each minute as long as the balloon was in sight. The points locating the projections have been computed from the altitude and selected readings of these angles. The variations in wind direction and velocity with altitude, as well as the general wind direction and velocity, seem to be in direct relation to the above-described pressure distribution at all altitudes reached by these soundings.

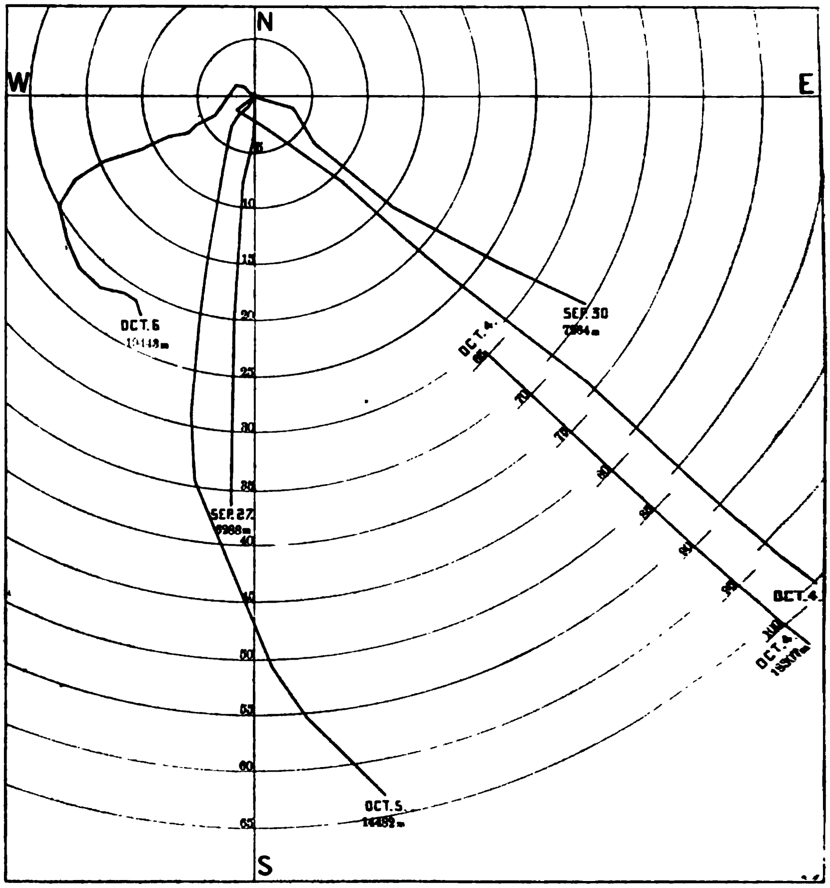

FIG. 8.—Horizontal projections of the paths of the balloons set free at Indianapolis, September 27 to October 6, 1909.

The simultaneous observations at two points during the passing of the first anticyclone are of especial interest.

Changes in wind direction with altitude are at times very abrupt, for example, the ascensions of October 5 and 6 at Omaha. The points

of sharp turning into (in these cases) a westerly wind have been marked with a (X) and the altitudes. At the time these ascensions were being made, a well-formed low was advancing toward the station from the northwest.

Further discussion of these data will follow when the data from other series of ascensions already made or in contemplation have been studied.

Sounding balloon ascensions.

SEPTEMBER 25, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100 \text{ m.}}$	Relative humidity.	Wind.		Remarks.
						Direction.	Velocity.	
p. m.	*m.*	*mm.*	*°C*		*Per ct.*		*m. p. s.*	
3:10...	312	742.4	22.0	....	....	E. 40° S.	5.6	Balloon launched.
3:14...	1148	672.6	10.0	1.4	....	E. 40° S.	5.6	
3:18...	1758	624.6	7.0	0.5	....	S. 39° W.	1.0	Meteorograph clock stopped; subsequent altitudes computed from ascensional rate.
3:20...	2122	....	....	....	....	N. 5° W.	1.7	
3:25...	3027	....	....	....	....	W. 38° N.	3.5	
3:30...	3932	....	....	....	....	N. 27° W.	6.7	
3:35...	4837	....	....	....	....	N. 19° W.	6.5	
3:40...	5742	....	....	....	....	N. 7° E.	3.8	
3:45...	6647	....	....	....	....	N. 35° E.	9.8	
3:50...	7552	....	....	....	....	E. 42° N.	14.0	
3:55...	8457	....	....	....	....	N. 45° E.	12.8	
4:00...	9362	....	....	....	....	N. 16° E.	13.3	
4:03...	9905	....	−56.8	....	....	N. 23° W.	11.9	Balloon burst; highest altitude and lowest temperature.

Base stations.—Starting point, Fort Omaha, Nebr; lat. 41° 19′, long. 95° 57′, alt. 312 m. Landing point, Louisville, Nebr.; lat. 41° 00′, long. 96° 09′, alt. 317 m. Distance between, 37 km.

Time.—Hour (90th meridian time) of starting, 3:10 p. m.

Balloons.—Number, 1. Kind, rubber. Maker, A. Paturel. Began to fill, 2:30 p. m. Filled, 2:50 p. m. Gas, hydrogen. Cubic contents, 3.6 cu. m. Ascensional force, 1 kg. Rate of ascent, 3.0 mps.

Meteorograph.—Bosch. No. 255.

Notes.—The sky was cloudless.

Sounding balloon ascensions.

SEPTEMBER 27, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100 \text{ m.}}$	Relative humidity.	Wind. Direction.	Wind. Velocity.	Remarks.
p. m.	*m.*	*mm.*	°C.		*Per ct.*		*m. p. s.*	
2:58...	312	741.6	19.6	....	44	S. 27° W.	3.8	Balloon launched.
3:04...	1176	669.6	12.2	0.8	39	S. 27° W.	3.8	Small inversion.
3:05...	1387	652.9	13.0	− 0.6	34	W. 29° S.	4.1	
3:12...	1912	612.7	6.6	1.2	45	N. 41° E.	3.5	
3:14...	2827	547.9	6.3	0.0	32	W. 21° N.	2.9	
3:20...	3717	491.0	2.1	0.5	20	N. 30° W.	4.6	
3:27...	4816	427.6	− 4.6	0.6	12	N. 2° W.	9.3	
3:36...	6257	354.6	−14.9	0.7	....	N. 12° E.	15.0	
3:44...	7554	297.3	−27.8	1.0	....	N. 21° E.	17.0	
3:50...	8639	254.7	−38.6	1.0	....	N. 25° E.	18.6	Balloon disappeared.
3:55...	9803	214.1	−48.8	0.9	....	....	....	
3:56...	10075	205.4	−49.2	0.1	....	....	....	
4:01...	11010	177.7	−55.2	0.6	....	....	....	
4:08...	12062	....	−63.2	0.7	....	....	....	Pressure pen not recording. Highest altitude; lowest temperature.
4:10...	11214	171.8	−58.2	0.7	....	....	....	
4:13...	10198	201.4	−51.0	0.4	....	....	....	
4:15...	9609	220.4	−48.6	0.9	....	....	....	
4:17...	8737	251.1	−40.5	1.1	....	....	....	
4:21...	7082	292.1	−29.2	1.0	....	....	....	
4:25...	6397	348.1	−16.6	0.8	....	....	....	
4:31...	4816	427.6	− 4.4	0.6	....	....	....	
4:34...	3908	479.4	0.8	0.5	....	....	....	
4:37...	3219	522.2	4.4	0.5	....	....	....	
4:43...	1480	644.9	12.2	− 0.5	....	....	....	Small inversion.
4:44...	1254	662.6	11.0	0.9	....	....	....	
4:48...	254	746.0	20.2	....	....	....	....	Balloon landed.

Base stations.—Starting point, Fort Omaha, Nebr.; lat. 41° 19′, long. 95° 57′, alt. 312 m. Landing point, Syracuse, Nebr.; lat. 40° 38′, long. 96° 11′, alt. 254 m Distance between, 76 km.

Time.—Hour (90th meridian time) of starting, 2:58 p. m.; of landing, 4:48 p. m.

Balloons.—Number, 1. Kind, rubber. Maker, A. Paturel. Began to fill 2:41 p. m. Filled, 2:46 p. m. Gas, hydrogen. Cubic contents, 3.9 cu. m. Ascensional force, 1 kg. Rate of ascent, 2.8 mps. Rate of descent, 4.9 mps.

Meteorograph.—Bosch. No. 201.

Notes.—The sky was cloudless.

Sounding balloon ascensions.

SEPTEMBER 28, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100 \text{ m.}}$	Relative humidity.	Wind. Direction.	Wind. Velocity.	Remarks.
p. m.	*m.*	*mm.*	*° C.*		*Per ct.*		*m. p. s.*	
3:30...	312	734.2	28.2	......	33	W. 7° S.	6.8	Balloon launched.
3:35...	934	683.7	22.0	1.0	29	W. 7° S.	6.8	
3:39...	1926	608.4	13.6	0.8	......	W. 17° N.	13.6	
3:40...	2079	597.4	13.5	0.0	......	N. 29° W.	13.7	
3:45...	2743	551.5	8.4	0.8	46	N. 23° W.	12.9	
3:50...	3615	495.4	1.4	0.8	57	N. 14° W.	14.9	
3:54...	4374	450.2	− 4.8	0.8	65	N. 13° W.	13.9	Small inversion.
3:55...	4568	439.2	− 4.6	− 0.1	62	N. 17° W.	11.7	
4:01...	5454	391.8	−10.8	0.7	53	N. 10° W.	8.6	
4:07...	6487	341.8	−18.4	0.7	53	N. 22° W.	11.6	
4:13...	7705	289.4	−27.0	0.7	67	N. 19° W.	19.5	
4:18...	8579	255.8	−34.4	0.9	48	N. 28° W.	20.4	
4:24...	9851	212.6	−41.6	0.6	46	N. 19° W.	25.3	
4:28...	11106	176.2	−47.4	0.5	46	N. 18° W.	33.8	
4:35...	13280	126.3	−52.1	0.2	46	N. 8° W.	24.4	
4:38...	14106	111.1	−53.8	0.2	46	N. 11° W.	16.7	
4:42...	14983	96.9	−53.9	0.0	47	N. 8° W.	10.0	Upper inversion reached.
4:43...	15766	85.8	−52.3	− 0.2	47	N. 13° W.	9.6	
4:48...	16952	71.1	−50.0	− 0.2	46	N. 10° W.	9.6	Highest altitude.
4:52...	15637	86.7	−54.6	0.1	45	N. 00° —.	11.0	Upper inversion left; lowest temperature.
4:55...	13887	113.9	−53.1	0.2	46	N. 00° —	22.5	
5:01...	10787	183.5	−47.7	0.5	48	....	....	
5:02...	9637	218.0	−42.0	0.7	48	....	....	
5:04...	8464	258.5	−33.8	0.6	49	....	....	
5:05...	7349	302.5	−26.9	1.1	53	....	....	
5:07...	6459	341.5	−17.4	0.5	52	....	....	
5:08...	5457	389.9	−12.2	0.5	51	....	....	
5:10...	4477	442.8	− 7.3	0.8	51	....	....	
5:12...	3537	498.9	− 0.1	1.0	48	....	....	
5:14...	2791	547.0	7.6	0.9	48	....	....	
5:17...	2276	582.1	12.0	0.4	49	....	....	
5:18...	1234	658.9	16.6	0.9	......	....	....	
5:19...	360	729.5	24.5	....	......	....	....	Balloon landed.

Base stations.—Starting point, Fort Omaha, Nebr.; lat. 41° 19′, long. 95° 57′, alt. 312 m. Landing point, Rockport, Mo.; lat. 40° 24′; long. 95° 31′, alt. 360 m. Distance between, 106 km.

Time.—Hour (90th meridian time) of starting, 3:30 p. m.; of landing, 5:19 p. m.

Balloons.—Number, 1. Kind, rubber. Maker, A. Paturel. Began to fill, 3:12 p. m. Filled, 3:17 p. m. Gas, hydrogen. Cubic contents, 3.6 cu. m. Ascensional force, 1 kg. Rate of ascent, 3.5 mps. Rate of descent, 8.8 mps.

Meteorograph.—Bosch. No. 251.

Notes.—The sky was cloudless.

Sounding balloon ascensions.

SEPTEMBER 30, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100 \text{ m.}}$	Relative humidity.	Wind. Direction.	Wind. Velocity.	Remarks.
p. m.	*m.*	*mm.*	*° C.*		*Per ct.*		*m. p. s.*	
2:59...	312	735.8	21.5	....	54	S. 36° E.	2.2	Balloon launched.
3:04...	1028	676.6	15.2	0.9	....	S. 36° E.	2.2	
3:06...	1454	643.2	14.3	0.2	....	E. 15° S.	2.2	Isothermal.
3:08...	1832	615.0	14.3	0.0	....	N. 30° W.	4.2	
3:11...	2399	574.5	9.0	0.9	....	N. 21° W.	6.0	
3:12...	2534	565.2	8.7	0.2	....	N. 11° W.	6.0	
3:21...	4159	461.2	− 9.1	1.1	....	N. 29° W.	5.2	
3:28...	5139	405.6	−15.5	0.7	....	N. 39° W.	4.0	
3:32...	5842	369.0	−23.9	1.2	....	N. 45° W.	7.5	
3:41...	7370	297.6	−37.2	0.9	....	N. 45° W.	8.8	
3:49...	8762	241.9	−50.7	1.0	....	W. 41° N.	9.7	
3:52...	9283	....	−55.2	0.9	....	W. 33° N.	9.9	Pressure pen not recording from 3:49 to 4:21 p. m. Intervening altitudes computed from rates of ascent and descent.
3:54...	9677	....	−56.2	0.2	....	W. 7° N.	13.4	
4:00...	10700	....	−60.9	0.5	....	W. 17° N.	13.1	
4:06...	11812	....	−65.2	0.3	....	W. 12° N.	10.2	Highest altitude; lowest temperature.
4:12...	10404	....	−62.5	0.3	....	W. 6° N.	14.5	
4:17...	9217	....	−58.7	1.0	....	W. 25° N.	20.7	
4:21...	8308	255.8	−49.8	1.0	....	W. 34° N.	13.4	Balloon disappeared.
4:26...	7140	304.3	−37.7	0.8	....	....	....	
4:31...	5780	369.0	−27.0	0.9	....	....	....	
4:37...	4478	440.2	−15.8	1.0	....	....	....	
4:40...	3610	492.9	− 7.1	1.3	....	....	....	
4:46...	2540	563.6	6.3	0.5	....	....	....	
4:51...	1244	659.1	13.1	− 0.2	....	....	....	Small inversion.
4:52...	1144	667.0	11.5	1.3	....	....	....	
4:56...	426	726.1	21.2	....	....	....	....	Balloon landed.

Base stations.—Starting point, Fort Omaha, Nebr.; lat. 41° 19′, long. 95° 57′, alt. 312 m. Landing point, Emerson, Iowa; lat. 41° 01′, long. 95° 25′, alt. 426 m. Distance between, 53 km.

Time.—Hour (90th meridian time) of starting, 2:59 p. m.; of landing, 4:56 p. m.

Balloons.—Number, 1. Kind, rubber. Maker, A. Paturel. Began to fill, 2:44 p. m. Filled, 2:48 p. m. Gas, hydrogen. Cubic contents, 3.6 cu. m. Ascensional force, 1 kg. Rate of ascent, 2.9 mps. Rate of descent, 3.8 mps.

Meteorograph.—Bosch. No. 206.

Notes.—The sky was cloudless, but there was light haze.

Sounding balloon ascensions.

OCTOBER 4, 1909.

Time.	Altitude.	Pressure.	Temperature.	Δt 100 m.	Relative humidity.	Wind. Direction.	Wind. Velocity.	Remarks.
p. m.	*m.*	*mm.*	*° C.*		*Per ct.*		*m. p. s.*	
3:38...	312	737.5	26.2	....	53	E. 26° S.	1.7	Balloon launched.
3:42...	824	695.3	21.5	0.9	....	E. 26° S.	1.7	Isothermal.
3:43...	979	682.9	21.5	0.0	....	S. 19° W.	3.2	
3:47...	1637	632.1	14.2	1.1	....	S. 19° W.	3.2	
3:51...	2235	588.1	6.1	1.4	....	S. 15° W.	4.0	
3:55...	2924	540.1	0.7	0.8	....	S. 12° W.	3.4	Meteorograph clock stopped, but ran for a brief interval at a high altitude.
....	10273	195.5	−52.6	0.7	....	....	....	
....	12439	139.1	−58.3	0.3	....	....	....	Highest altitude; lowest temperature.

Base stations.—Starting point, Fort Omaha, Nebr.; lat. 41° 19′, long. 95° 57′, alt. 312 m. Landing point, Henderson, Iowa; lat. 41° 09′, long. 95° 26′, alt. 314 m. Distance between, 47 km.

Time.—Hour (90th meridian time) of starting, 3:38 p. m.

Balloons.—Number, 1. Kind, rubber. Maker, A. Paturel. Began to fill, 3:11 p. m. Filled, 3:18 p. m. Gas, hydrogen. Cubic contents, 3.6 cu. m. Ascensional force, 1 kg. Rate of ascent, 2.6* mps.

Meteorograph.—Bosch. No. 217.

Notes.—The balloon was in sight for 2 h. 3 m., and had not burst when it disappeared. It is probable that it leaked, and that its rate of ascent decreased considerably with increasing altitude.

There were a few Ci-St. from the northwest near the horizon.

* From 3:38 until 3:55 p. m.; not known thereafter.

Sounding balloon ascensions.

OCTOBER 5, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\text{ m.}}$	Relative humidity.	Wind. Direction.	Wind. Velocity.	Remarks.
p. m.	m.	mm.	°C.		Per ct.		m. p. s.	
3:03...	312	738.6	27.6	....	46	S. 42° E.	4.7	Balloon launched.
3:06...	789	699.4	23.5	0.9	....	S. 42° E.	4.7	
3:07...	886	691.6	22.8	0.7	....	S. 2° W.	4.3	
3:12...	1894	614.6	14.6	0.8	....	S. 23° W.	7.5	
3:17...	2777	552.3	4.1	1.2	....	S. 23° W.	7.4	
3:18...	3029	535.4	3.7	0.2	....	S. 23° W.	7.5	
3:26...	4452	447.3	− 8.9	0.9	....	S. 30° W.	3.0	Isothermal.
3:27...	4612	438.1	− 8.9	0.0	....	S. 36° W.	3.5	
3:35...	6170	356.1	−23.3	0.9	....	S. 36° W.	3.6	
3:36...	6238	352.8	−23.5	0.3	....	S. 10° W.	3.5	
3:42...	7476	296.7	−34.6	1.1	....	S. 10° W.	3.5	
3:50...	8913	....	−46.7	0.8	....	W. 00° —	0.4	Pressure pen not recording from 3:42 to 4:43 p. m. Intervening altitudes computed from rates of ascent and descent.
3:56...	10011	....	−57.6	1.0	....	W. 36° N.	3.7	
4:05...	11658	....	−63.8	0.4	....	W. 28° N.	6.9	Upper inversion reached.
4:11...	12756	....	−62.1	− 0.2	....	W. 17° N.	6.1	
4:12...	12939	....	−62.9	0.5	....	N. 37° W.	5.8	
4:19...	14286	....	−57.8	− 0.5	....	N. 37° W.	2.7	Highest altitude. Balloon burst.
4:22...	13444	....	−63.1	− 0.1	....	W. 5° N.	5.5	
4:23...	13176	....	−63.3	− 0.3	....	W. 10° N.	9.5	
4:25...	12548	....	−65.0	0.4	....	W. 10° N.	8.5	Lowest temperature. Upper inversion left.
4:30...	11095	....	−59.6	0.7	....	W. 10° N.	9.9	
4:37...	9152	....	−46.9	0.8	....	W. 5° N.	7.4	
4:43...	7474	296.4	−33.5	1.0	....	S. 44° W.	3.2	
4:47...	6490	340.1	−23.7	0.8	....	S. 33° W.	4.6	
4:52...	4879	421.7	−10.9	0.2	....	S. 33° W.	2.8	
4:54...	4530	441.3	−10.1	1.0	....	S. 22° W.	4.6	
4:58...	3470	505.1	0.5	0.2	....	S. 22° W.	2.5	Balloon disappeared.
5:00...	2983	536.7	1.4	0.9	....	....	....	
5:03...	2038	602.6	10.3	0.9	....	....	....	
5:08...	1100	673.6	19.1	0.3	....	....	....	
5:09...	785	698.8	20.0	1.1	....	....	....	
5:11...	453	726.2	23.5	....	....	....	....	Balloon landed.

Base stations.—Starting point, Fort Omaha, Nebr.; lat. 41° 19′, long. 95° 57′, alt. 312 m. Landing point, Neola, Iowa; lat. 41° 28′; long. 95° 37′, alt. 453 m. Distance between, 35 km.

Time.—Hour (90th meridian time) of starting, 3:03 p. m.; of landing, 5:11 p. m.

Balloons.—Number, 1. Kind, rubber. Maker, A. Paturel. Began to fill, 2:49 p. m. Filled, 2:52 p. m. Gas, hydrogen. Cubic contents, 3.6 cu. m. Ascensional force, 1 kg. Rate of ascent, 3.2 mps. Rate of descent, 4.5 mps.

Meteorograph.—Bosch. No. 253.

Notes.—The sky was cloudless.

Sounding balloon ascensions.

OCTOBER 6, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\ m.}$	Relative humidity.	Wind.		Remarks.
						Direction.	Velocity.	
p. m.	*m.*	*mm.*	*°C.*		*Per ct.*		*m. p. s.*	
3:58...	312	734.2	28.5		27	S. 5° W.	13.4	Balloons launched.
4:02...	1440	645.2	21.4	0.6		S. 5° W.	13.4	
4:07...	2692	556.1	8.6	1.0		S. 16° W.	11.7	Small inversion.
4:08...	3060	531.9	9.4	− 0.2		W. 34° S.	13.2	
4:11...	3911	479.3	2.8	0.8		W. 26° S.	14.2	
4:15...	5090	411.9	− 7.9	0.8		W. 13° S.	10.2	One balloon burst.
4:23...	3664	492.2	1.8	0.8		W. 11° S.	9.8	Disappeared.
4:28...	2711	553.1	9.8	− 0.7				Small inversion.
4:29...	2503	567.2	8.3	0.9				
4:37...	1217	661.0	19.7	0.8				
4:42...	365	729.5	26.7					Balloons landed; burst balloon apparently detached; remaining balloon and meteorograph again ascended.
4:58...	1186	663.7	21.4	0.6				
5:23...	2535	565.5	9.0	0.9				Small inversion.
5:26...	2812	546.9	10.1	− 0.4				
5:37...	3499	503.0	5.4	0.7				
5:55...	4656	435.0	− 6.2	1.0				
6:13...	5738	377.7	−16.4	0.9				
6:28...	6777	328.2	−24.6	0.8				Meteorograph clock stopped.
			−68.6					Lowest temperature.
	15934	82.5						Highest altitude.

Base stations.—Starting point, Fort Omaha, Nebr.; lat. 41° 19′, long. 95° 57′, alt. 312 m. Landing point, Rockwell City, Iowa; lat. 42° 44′, long. 94° 38′, alt. 373 m. Distance between, 167 km.

Time.—Hour (90th meridian time) of starting, 3:58 p. m.

Balloons.—Number, 2*. Kind, rubber. Maker, A. Paturel. Began to fill, 2:45 p. m. Filled, 3:00 p. m. Gas, hydrogen. Cubic contents, 7.2* cu. m. Ascensional force, 1.5* kg. Rate of ascent, 4.7* mps. Rate of descent, 3.0* mps.

Meteograph.—Bosch. No. 188.

Notes.—One balloon burst at 4:15 p. m. and both landed at 4:42 p. m. The burst balloon apparently became detached and the remaining balloon made a second ascension. The figures marked with an asterisk (*) apply to the first ascension only. In the second ascension there was one balloon; cubic contents, 3.6 cu. m.; ascensional force, 0.8 kg.; rate of ascent until 6:28 p. m., when the meteorograph clock stopped, 1.0 m. p. s.

The sky was cloudless.

Sounding balloon ascensions.

OCTOBER 7, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100 m.}$	Relative humidity.	Wind.		Remarks.
						Direction.	Velocity.	
p. m.	m.	mm.	°C.		Per ct.		m. p. s.	
3:09...	312	728.6	27.8	......	33	S. 6° E.	15.8	Balloons launched.
3:12...	1253	654.7	21.2	0.7	38	S. 4° E.	15.8	
3:15...	2401	571.4	9.0	1.1	54	S. 2° W.	22.1	
3:18...	3213	517.5	1.8	0.9	61	S. 9° W.	21.9	Small inversion.
3:19...	3485	500.6	2.2	0.0	53	S. 14° W.	26.3	
3:22...	4312	452.7	− 3.1	0.6	57	S. 14° W.	26.3	
3:27...	5595	383.4	−14.1	1.3	52	S. 12° W.	19.2	Disappeared in cloud.
3:28...	5847	371.1	−13.6	0.0	54	....	......	Small inversion.
3:31...	6649	326.4	−19.9	0.6	54	....	......	
3:36...	7801	286.3	−27.6	0.8	53	....	......	
3:40...	8825	247.8	−35.9	0.8	52	....	......	
3:44...	9742	216.9	−43.4	0.8	52	....	......	
3:48...	10778	186.1	−51.2	0.8	52	....	......	
3:51...	11547	166.0	−56.0	0.6	52	....	......	Upper inversion reached.
3:56...	12699	139.8	−55.6	0.0	52	....	......	
4:00...	13533	122.9	−53.2	− 0.3	50	....	......	
4:06...	14939	98.2	−52.9	− 0.2	48	....	......	Highest altitude.
4:07...	13877	113.6	−57.1	0.1	49	....	......	Lowest temperature.
4:09...	12357	144.4	−54.9	− 0.2	48	....	......	
4:12...	11388	169.1	−56.8	0.3	50	....	......	Upper inversion left.
4:15...	9610	216.8	−50.8	1.6	54	....	......	
4:19...	8956	241.5	−40.1	0.8	55	....	......	
4:25...	7422	300.0	−27.8	0.7	61	....	......	
4:30...	6194	353.9	−19.2	0.6	60	....	......	
4:32...	5643	380.1	−16.0	0.7	64	....	......	
4:36...	4274	452.4	− 6.2	0.9	56	....	......	
4:39...	3351	507.9	2.0	− 0.6	62	....	......	Small inversion.
4:40...	3104	523.3	0.4	0.9	56	....	......	
4:42...	2260	580.3	8.2	0.9	81	....	......	
4:45...	1068	668.0	19.4	0.9	68	....	......	
4:46...	442	717.3	24.8	......	52	....	......	Balloons landed.

Base stations.—Starting point, Fort Omaha, Nebr.; lat. 41° 19′, long. 95° 57′, alt. 312 m. Landing point, Idagrove, Iowa; lat. 42° 23′, long. 95° 28′, alt. 442 m. Distance between, 126 km.

Time.—Hour (90th meridian time) of starting, 3:09 p. m.; of landing, 4:46 p. m.

Balloons.—Number, 2. Kind, rubber. Maker, A. Paturel. Began to fill, 2:30 p. m. Filled, 2:50 p. m. Gas, hydrogen. Cubic contents, 7.2 cu. m. Ascensional force, 1.5 kg. Rate of ascent, 4.4 mps. Rate of descent, 5.9 mps.

Meteorograph.—Bosch. No. 292.

Notes.—The meteorograph clock stopped at 3:56 p. m., but ran intermittently thereafter; times of levels after 3:56 are estimated.

There were 9/10 A.-St., moving from the south-southwest.

Sounding balloon ascensions.

OCTOBER 9, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100 m.}$	Relative humidity.	Wind. Direction.	Wind. Velocity.	Remarks.
p. m.	*m.*	*mm.*	*° C.*		*Per ct.*		*m. p. s.*	
3:17...	312	731.9	9.8	....	84	NW.	5.4	Balloons launched.
3:19...	884	682.9	5.0	0.8	100	NW.	....	Disappeared in clouds
3:20...	1254	653.5	5.1	− 0.1	100	NW.	....	Small inversion. Highest altitude.
3:22...	816	688.5	4.6	0.9	97	NW.	....	Small inversion. Lowest temperature.
3:24...	281	734.7	9.4	....	86	NW.	5.4	Balloons landed.

Base stations.—Starting point, Fort Omaha, Nebr.; lat. 41° 19′, long. 95° 57′, alt. 312 m. Landing point, Omaha, Nebr.; lat. 41° 19′, long. 95° 57′, alt. 281 m. Disance between, 1 km.

Time.—Hour (90th meridian time) of starting, 3:17 p. m.; of landing, 3:24 p. m.

Balloons.—Number, 2. Kind, rubber. Maker, A. Paturel. Began to fill, 2:35 p. m. Filled, 2:48 p. m. Gas, hydrogen. Cubic contents, 7.3 cu. m. Ascensional force, 1.5 kg. Rate of ascent, 5.2 mps. Rate of descent, 3.9 mps.

Meteorograph.—Bosch. No. 186.

Notes.—There were 10/10 St. from the northwest. The balloons entered the clouds at an altitude of about 500 m. above sea level.

OCTOBER 10, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100 m.}$	Relative humidity.	Wind. Direction.	Wind. Velocity.	Remarks.
p. m.	*m.*	*mm.*	*° C.*		*Per ct.*		*m. p. s.*	
2:59...	312	729.7	10.4	....	80	N. 23° W.	17.9	Balloons launched.
3:03...	1408	638.2	2.4	0.7	51	N. 23° W.	17.9	
3:04...	1692	616.1	2.2	0.1	76	N. 13° W.	23.7	Disappeared in clouds.
3:11...	3629	482.7	− 5.8	0.4	97			
3:17...	5635	370.7	−21.2	0.8	85	....	....	Small inversion.
3:18...	5894	357.9	−21.1	0.0	76	....	....	
3:25...	8045	264.1	−38.4	0.8	49	....	....	Highest altitude; lowest temperature.
3:32...	5694	366.9	−21.4	0.7	52	....	....	
3:37...	3812	470.7	− 8.6	0.5	....	....	....	
3:43...	1710	614.5	1.6	0.1	65	....	....	
3:44...	1347	642.9	1.8	0.8	66	....	....	
3:46...	220	737.8	10.3	....	66	....	....	Balloons landed.

Base stations.—Starting point, Fort Omaha, Nebr.; lat. 41° 19′, long. 95° 57′, alt. 312 m. Landing point, Bartlett, Iowa; lat. 40° 54′, long. 95° 47′, alt. 220 m. Distance between, 49 km.

Time.—Hour (90th meridian time) of starting, 2:59 p. m.; of landing, 3:46 p. m.

Balloons.—Number, 2. Kind, rubber. Maker, A. Paturel. Began to fill, 2:30 p. m. Filled, 2:48 p. m. Gas, hydrogen. Cubic contents, 7.3 cu. m. Ascensional force, 1.5 kg. Rate of ascent, 5.0 mps. Rate of descent, 6.1 mps.

Meteorograph.—Bosch. No. 199.

Notes.—There were 6/10 to 8/10 St., from the north-northwest. Light rain fell from shortly before the ascension until 3:05 p. m.

Sounding balloon ascensions.

OCTOBER 11, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100 \text{ m.}}$	Relative humidity.	Wind. Direction.	Wind. Velocity.	Remarks.
p. m.	*m.*	*mm.*	*° C.*		*Per ct.*		*m. p. s.*	
3:09...	312	735.0	4.6	....	59	N. 24° W.	16.7	Balloons launched.
3:12...	1100	665.9	− 6.2	1.2	62	N. 24° W.	16.7	
3:16...	2080	586.9	−17.7	1.2	84	N. 35° W.	21.2	Disappeared in clouds.
3:22...	3598	477.6	−30.8	0.9	63	....	....	Isothermal.
3:23...	3806	463.8	−30.8	0.0	58	....	....	
3:28...	4965	395.0	−39.2	0.7	46	....	....	Isothermal.
3:29...	5075	387.6	−39.2	0.0	46	....	....	
3:36...	7281	284.0	−50.8	0.5	41	....	....	Upper inversion reached.
3:37...	7562	271.8	−50.4	− 0.1	41	....	....	
3:42...	8582	234.2	−53.8	0.3	38	....	....	
3:45...	9564	202.9	−51.9	− 0.2	38	....	....	
3:48...	10161	184.3	−52.3	0.1	32	....	....	
3:53...	11508	149.4	−51.4	− 0.1	....	....	....	
3:58...	13140	116.7	−54.8	0.5	....	....	....	Lowest temperature.
4:01...	13661	108.3	−52.8	− 0.4	30	....	....	
4:05...	14674	92.0	−53.6	0.1	28	....	....	
4:09...	15791	77.7	−53.8	0.0	28	....	....	
4:12...	16885	66.4	−52.5	− 0.1	29	....	....	
4:15...	18041	55.2	−51.8	− 0.1	26	....	....	Highest altitude.
4:18...	17040	64.9	−52.6	....	31	....	....	
4:21...	17199	63.4	−49.0	....	26	....	....	Meteorograph clock stopped.

Base stations.—Starting point, Fort Omaha, Nebr.; lat. 41° 19′, long. 95° 57′, alt. 312 m. Landing point, Hurdland, Mo.; lat. 40° 09′, long. 92° 20′, alt. 252 m. Distance between, 380 km.

Time.—Hour (90th meridian time) of starting, 3:09 p. m.

Balloons.—Number, 2. Kind, rubber. Maker, A. Paturel. Began to fill, 2:38 p. m. Filled, 2:49 p. m. Gas, hydrogen. Cubic contents, 7.3 cu. m. Ascensional force, 1.5 kg. Rate of ascent, 4.5 mps.

Meteorograph.—Bosch. No. 258.

Notes.—There were about 4/10 St.-Cu., moving rapidly from the northwest. Light snow fell from 3:10 to 3:14 p. m.

Sounding balloon ascensions.

OCTOBER 12, 1909.

Time.	Altitude.	Pressure.	Temperature.	Δt / 100 m.	Relative humidity.	Wind. Direction.	Wind. Velocity.	Remarks.
p. m.	*m.*	*mm.*	°*C.*		*Per ct.*		*m. p. s.*	
2:33...	312	735.0	3.2	....	48	W. 29° N.	7.8	Balloons launched.
2:36...	1209	656.6	− 5.8	1.0	46	W. 28° N.	7.8	
2:40...	1819	607.0	−11.3	0.9	67	W. 29° N.	9.2	Small inversion.
2:41...	2045	589.4	− 8.8	− 1.1	48	W. 35° N.	14.1	
2:46...	3263	502.9	−12.8	0.3	33	W. 31° N.	19.3	Disappeared in clouds.
2:50...	4185	445.3	−15.0	0.2	26	....	....	
2:53...	5036	397.3	−19.0	0.5	23	....	....	
2:56...	5951	350.9	−23.9	0.5	23	....	....	
2:59...	6835	310.9	−24.2	0.0	23	....	....	
3:04...	7998	264.5	−31.2	0.6	19	....	....	
3:09...	9392	216.5	−40.2	0.6	22	....	....	
3:15...	11320	162.1	−51.8	0.6	18	....	....	
3:20...	13078	123.6	−52.4	0.0	20	....	....	Upper inversion reached; lowest temperature.
3:28...	16015	78.8	−49.6	− 0.1	18	....	....	
3:36...	19212	48.4	−50.0	0.0	18	....	....	
3:42...	20177	42.0	−33.9	− 1.7	17	....	....	
3:49...	23653	25.9	−24.4	− 0.3	17	....	....	
3:53...	24119	24.3	−27.2	0.3	15	....	....	Highest altitude.
3:56...	23630	25.9	−27.5	− 0.3	17	....	....	
4:03...	20467	40.3	−36.6	− 0.4	15	....	....	
4:09...	19295	48.3	−41.0	....	17	....	....	Meteorograph clock stopped.

Base stations.—Starting point, Fort Omaha, Nebr.; lat. 41° 19′, long. 95° 57′, alt. 312 m. Landing point, Palmyra, Mo.; lat. 39° 47′, long. 91° 32′, alt. 198 m. Distance between, 420 km.

Time.—Hour (90th meridian time) of starting, 2:33 p. m.

Balloons.—Number, 2. Kind, rubber. Maker, A. Paturel. Began to fill, 2:03 p. m. Filled, 2:12 p. m. Gas, hydrogen. Cubic contents, 7.3 cu. m. Ascensional force, 1.5 kg. Rate of ascent, 5.0 mps.

Meteorograph.—Bosch. No. 181.

Notes.—There were about 5/10 Cu., from the north-northwest.

Sounding balloon ascensions.

SEPTEMBER 27, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\ m.}$	Relative humidity.	Wind.		Remarks.
						Direction.	Velocity.	
p. m.	*m.*	*mm.*	*°C.*		*Per ct.*		*m. p. s.*	
4:23...	212	748.4	14.8	....	56	NNE.	3.6	Balloons launched.
4:28...	1119	670.2	0.7	1.6	64	N. 2° W.	6.8	
4:32...	1884	607.9	−11.4	1.6	78	N.	6.1	
4:33...	2091	591.8	−10.9	− 0.2	72	N.	7.5	
4:39...	3035	523.8	− 8.1	− 0.3	34	N. 15° E.	10.6	
4:49...	4590	426.3	−22.1	0.9	37	N. 3° E.	20.3	
4:51...	5034	401.6	−23.1	0.2	36	N.	20.3	
4:54...	5534	374.6	−28.0	1.0	30	N.	21.4	
4:58...	6288	337.1	−35.2	1.0	27	N.	24.6	Balloon burst.

Base stations.—Starting point, Indianapolis, Ind.; lat. 39° 46′, long. 86° 10′, alt. 212 m. Landing point, Columbus, Ind.; lat. 39° 12′, long. 85° 54′, alt. 192 m. Distance between, 65 km.

Time.—Hour (90th meridian time) of starting, 4:23 p. m.; of landing, 5:13 p. m.

Balloons.—Number, 1. Kind, rubber. Maker, A. Paturel. Began to fill, 2:30 p. m. Filled, 4:15 p. m. Gas, chem. H. Cubic contents, 3.6 cu. m. Ascensional force, 0.8 kg. Rate of ascent, 2.9 mps. Rate of descent, 6.8 mps.

Meteorograph.—Bosch. No. 189.

Notes.—2/10 Cu. from the north disappeared by 5:10 p. m.

Sounding balloon ascensions.

SEPTEMBER 30, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100\text{ m.}}$	Relative humidity.	Wind.		Remarks.
						Direction.	Velocity.	
p. m.	*m.*	*mm.*	*° C.*		*Per ct.*		*m. p. s.*	
3:50...	212	743.5	17.2	....	58	N.	5.4	Balloons launched.
3:57...	2026	596.8	0.6	0.9	95	N. 72° E.	8.4	
4:02...	2982	530.5	5.6	− 0.5	44	N. 40° W.	13.3	
4:10...	4385	445.2	− 3.0	0.6	30	N. 50° W.	17.3	
4:21...	6030	360.0	−16.8	0.8	29	N. 63° W.	17.5	
4:29...	7264	304.6	−26.9	0.8	29	N. 64° W.	16.7	Balloons lost in clouds.
4:37...	8535	255.2	−37.4	0.8	29	....	....	
4:52...	9996	206.1	−46.5	0.6	29	....	....	
4:58...	10980	178.1	−46.0	− 0.1	29	....	....	
5:06...	12538	141.5	−52.3	0.4	29	....	....	
5:20...	14606	102.8	−56.9	0.2	29	....	....	Upper inversion.
5:22...	14202	107.4	−58.0	− 0.3	29	....	....	
5:26...	12469	140.1	−55.3	0.2	29	....	....	
5:33...	10664	184.5	−47.7	0.4	29	....	....	
5:39...	9378	222.9	−46.4	0.1	29	....	....	
5:53...	6461	337.7	−24.0	0.8	34	....	....	
6:01...	4903	415.1	−10.7	0.9	34	....	....	
6:09...	2791	542.2	3.7	0.7	34	....	....	
6:13...	1722	619.2	0.7	0.3	....	....	....	
6:21...	197	745.0	14.4	....	....	....	....	Balloons landed.

Base stations.—Starting point, Indianapolis, Ind.; lat. 39° 46′, long. 86° 10′, alt. 212 m Landing point, Terrace Park, Ohio; lat. 39° 12′, long. 84° 30′, alt. 197 m. Distance between ,168 km.

Time.—Hour (90th meridian time) of starting, 3:50 p. m.; of landing, 6:12 p. m.

Balloons.—Number, 2. Kind, rubber. Maker, A. Paturel. Began to fill, 3:15 p. m. Filled, 3:45 p. m. Gas, chem. H. Cubic contents, 6.4 cu. m. Ascensional force, 0.7 kg. Rate of ascent, 2.7 mps. Rate of descent, 2.2 mps.

Meteorograph.—Bosch. No. 291.

Notes.—There were 2/10 St.-Cu. from the northwest.

Sounding balloon ascensions.

OCTOBER 4, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100 m.}$	Relative humidity.	Wind. Direction.	Wind. Velocity.	Remarks.
p. m.	*m.*	*mm.*	*°C.*		*Per ct.*		*m. p. s.*	
3:35...	212	747.7	20.9	....	43	NE.	3.6	Balloons launched.
3:42...	1799	619.5	9.0	0.7	....	N. 56° E.	4.8	
3:50...	2812	547.6	6.7	0.2	....	N. 60° W.	5.4	
4:01...	4408	449.0	− 3.9	0.6	....	N. 55° W.	13.6	
4:10...	5650	382.7	−13.4	0.8	....	N. 51° W.	13.9	
4:14...	6387	346.8	−18.2	0.7	....	N. 51° W.	20.4	
4:27...	8199	270.3	−31.6	0.7	....	N. 50° W.	20.0	
4:37...	9821	213.9	−42.4	0.7	....	N. 50° W.	27.8	
4:46...	11632	162.4	−54.3	0.7	....	N. 50° W.	30.9	Upper inversion entered.
4:53...	13475	122.0	−53.6	0.0	....	N. 50° W.	34.6	
5:01...	15457	89.5	−54.3	0.0	....	N. 50° W.	22.2	
5:07...	16735	73.4	−58.4	0.3	....	N. 50° W.	6.9	
5:16...	18307	57.3	−57.0	− 0.1	....	N. 50° W.	4.8	
5:21...	15863	81.6	−62.0	− 0.2	....	....	....	
5:24...	14663	99.2	−60.9	0.1	....	....	....	
5:31...	12362	142.9	−56.5	0.2	....	....	....	Upper inversion left.
5:37...	10919	179.0	−54.1	0.2	....	....	....	
5:42...	9501	222.1	−44.7	0.7	....	....	....	
5:50...	7468	297.6	−29.4	....	....	....	....	Clock stopped.

Base stations.—Starting point, Indianapolis, Ind.; lat. 39° 46′, long. 86° 10′, alt. 212 m. Landing point, Patriot, Ind.; lat. 38° 48′, long. 84° 45′, alt. 128 m. Distance between, 154 km.

Time.—Hour (90th meridian time) of starting, 3:35 p. m.; of landing, clock stopped.

Balloons.—Number, 2. Kind, rubber. Maker, A. Paturel. Began to fill, 2:30 p. m. Filled, 3:33 p. m. Gas, chem. H. Cubic contents, 6.4 cu. m. Ascensional force, 1.0 kg. Rate of ascent, 3.0 mps. Rate of descent, 5.0 mps.

Meteorograph.—Bosch. No. 311.

Notes.—The sky was cloudless.

Sounding balloon ascensions.

OCTOBER 5, 1909.

Time.	Altitude.	Pressure.	Temperature.	Δt / 100 m.	Relative humidity.	Wind. Direction.	Wind. Velocity.	Remarks.
p. m.	*m.*	*mm.*	*° C.*		*Per ct.*		*m. p. s.*	
3:22...	212	749.9	18.8	....	47	NNE.	3.1	Balloons launched.
3:26...	1238	663.7	9.6	0.9	60	N. 36° E.	4.6	
3:28...	1834	617.7	10.8	− 0.2	39	N. 55° E.	7.9	
3:33...	3143	526.6	2.8	0.6	21	N. 30° E.	4.5	
3:38...	4432	448.0	− 5.0	0.6	21	N. 13° E.	6.3	
3:48...	6463	343.5	−21.2	0.8	....	N. 9° E.	11.3	
3:53...	7454	299.9	−29.1	0.8	....	N. 9° E.	12.5	
4:02...	9006	240.8	−39.8	0.7	....	N. 7° E.	10.9	
4:10...	10347	197.9	−48.0	0.6	....	N. 6° E.	16.5	Upper inversion reached.
4:16...	11232	173.4	−49.6	0.2	....	N. 4° W.	16.7	
4:30...	13580	121.8	−49.4	0.0	....	N. 22° W.	21.5	
4:36...	14011	114.3	−45.4	− 1.0	....	N. 34° W.	14.7	
4:44...	14482	106.8	−39.0	− 1.4	....	N. 44° W.	20.8	Greatest altitude.

Base stations.—Starting point, Indianapolis, Ind.; lat. 39° 46′, long. 86° 10′, alt. 212 m. Landing point, Scottsburg, Ind.; lat. 38° 40′, long. 85° 47′, alt. 174 m. Distance between ,120 km.

Time.—Hour (90th meridian time) of starting, 3:22 p. m.; of landing, clock stopped.

Balloons.—Number, 2. Kind, rubber. Maker, A. Paturel. Began to fill, 2:00 p. m. Filled, 3:16 p. m. Gas, chem. H. Cubic contents, 6.4 cu. m. Ascensional force, 0.9 kg. Rate of ascent, 2.9 mps. Rate of descent, 2.9 mps.

Meteorograph.—Bosch. No. 196.

Notes.—The sky was cloudless.

Sounding balloon ascensions.

OCTOBER 6, 1909.

Time.	Altitude.	Pressure.	Temperature.	$\frac{\Delta t}{100 \text{ m.}}$	Relative humidity.	Wind. Direction.	Wind. Velocity.	Remarks.
p. m.	*m.*	*mm.*	*° C.*		*Per ct.*		*m. p. s.*	
2:57...	212	748.4	22.4	....	74	S. 70° E.	2.2	Balloons launched.
3:05...	1507	642.4	11.2	0.9	86	S. 58° E.	1.3	
3:08...	1997	602.9	11.2	0.0	57	S. 45° E.	2.5	
3:12...	3000	....	4.0	0.7	45	S. 78° E.	4.0	
3:17...	4026	276.6	− 3.3	0.7	34	N. 35° E.	4.8	
3:23...	5000	....	−11.5	0.8	34	N. 35° E.	4.2	
3:30...	6306	349.8	−22.4	0.8	34	N. 60° E.	4.0	
3:34...	7043	320.7	−27.9	0.7	34	N. 60° E.	4.0	
3:39...	8000	....	−36.4	0.9	34	N. 75° E.	7.1	
3:43...	9000	....	−45.2	0.9	34	N. 65° E.	10.8	
3:49...	10251	196.8	−56.3	0.9	34	N. 72° E.	10.1	
3:53...	11000	....	−58.6	0.3	34	N. 59° E.	11.9	
3:58...	12000	....	−61.6	0.3	34	N. 25° E.	10.0	
4:04...	13081	125.0	−65.0	0.3	34	N. 15° W.	9.6	Lowest temperature. Upper inversion reached.
4:08...	14000	....	−63.8	− 0.1	34	N. 20° W.	10.6	
4:13...	15000	....	−62.5	− 0.1	34	N. 50° W.	4.5	
4:20...	16297	74.4	−60.4	− 0.3	34	N. 80° W.	5.2	
4:26...	17500	....	−56.8	− 0.3	34	N. 54° W.	3.2	
4:31...	18500	....	−53.5	− 0.3	34	N. 25° W.	2.0	
4:35...	19443	45.2	−50.4	− 0.3	34	N. 24° W.	2.3	Highest altitude.

Base stations.—Starting point, Indianapolis, Ind.; lat. 39° 46′, long. 86° 10′, alt. 212 m. Landing point, Martinsville, Ind.; lat. 39° 25′, long. 86° 26′, alt. 182 m. Distance between, 47 km.

Time.—Hour (90th meridian time) of starting, 2:57 p. m.

Balloons.—Number, 2. Kind, rubber. Maker, A. Paturel. Began to fill, 2:00 p. m. Filled, 2:50 p. m. Gas, chem,. H. Cubic contents, 6.4 cu. m. Ascensional force, 1.2 kg. Rate of ascent, 3.1 mps. Rate of descent, 3.9 mps.

Meteorograph.—Bosch. No. 248.

Notes.—Clock stopped at 5:42 p. m. The sky was cloudless.

(V) STUDIES ON THE GENERAL CIRCULATION OF THE ATMOSPHERE.

FRANK H. BIGELOW. (Dated March 12, 1910.)

THE DISTRIBUTION OF THE TEMPERATURE, PRESSURE, DENSITY, AND VELOCITY OF MOTION OF THE ATMOSPHERE IN THE NORTHERN HEMISPHERE OF THE EARTH.

There have been two important efforts to solve the great problem of the general circulation of the earth's atmosphere, namely, those by Oberbeck and Ferrel, respectively, and several minor attempts to throw some light upon the several features of the problem, as by Hildebrandsson, Helmholtz, Teisserenc de Bort, Bjerknes, Bigelow, and others. The integrations by Oberbeck and Ferrel rely upon the assumption that the earth's atmosphere can be treated as a systematic vortex, in which the rings at any latitude on moving north or south contract and rotate more rapidly, or expand and rotate more slowly, according to their distance from the equator. The canal theory of temperature distribution is adopted by them, wherein the air flows from the equator toward the poles in the upper levels, and from the poles toward the equator in the lower levels, leaving a neutral horizontal plane of no north and south motion between them. In my International Cloud Report, 1898, doubt was expressed in detail as to the validity of the Ferrel or the Oberbeck solutions, which differ from each other distinctly, and especially it was shown that the canal theory, with the neutral plane, has no support in the cloud observations on the motions of the atmosphere. On the other hand, it was there shown decisively that northward and southward currents pass each other on the same levels, at all elevations from the surface upward, and that under the force of gravitation acting upon the warm and cold currents the local circulations of the cyclone and anticyclone are generated. These northward currents were described as the "leakage" currents from the Tropic Zone into the Temperate Zone, and their effect is to break up the high pressure belt into "centers of action," as locally induced by the configuration of the oceans and the continents.

The solution of this group of problems in reality depends upon the determination of the distribution of the temperature of the atmosphere at all levels and in all latitudes from the equator to the poles. Although the observations with balloons and kites are as yet far from being adequate for this great object, the necessary records being meager

in the Tropics and in the polar zones, yet enough data is now accessible to make it possible to draw up a plan of the temperature distribution that is appropriate and sufficient to produce the velocities that have been observed in the several latitudes and altitudes. In the International Cloud Report, and in later papers on the circulation of the atmosphere in the United States and the West Indies, together with other well-known data on velocities of the circulation, it has been possible to make a beginning in this direction. No pretense is made that the adopted temperature distribution will not need modification in many particulars, but this is not important now, as our main purpose is to discover the proper line of thought for future discussions of the problem.

After three trial computations, which were very laborious, we have adopted the temperature scheme given in fig. 1. From these temperatures the corresponding pressure in dynes or barometric units, density, and velocity of motion have been computed. These last values can be compared with the observed velocities at various latitudes and altitudes, and the comparison shows that the systems of computed and observed velocities are generally in fair agreement. Let a represent the observed fall in temperature in degrees centigrade per 1000 meters ascent in elevation, and a_0 the adiabatic rate for dry air; then let

$$n=\frac{a_0}{a}.$$

The ordinary values of n vary from

$$n=\frac{-9.8695^\circ}{-9.80}=+1.0071, \text{ to } n=\frac{-9.8695^\circ}{-5.50}=+1.7945.$$

Employ the group of formulas (38), (39), (40), (41) given in the Monthly Weather Review, June, 1906.

Pressure $$\log P=\log P_0+n\frac{k}{k-1}(\log T-\log T_0). \qquad (38)$$

Density $$\log \rho=\log \rho_0+\frac{n}{k-1}(\log T-\log T_0). \qquad (39)$$

Gas constant $$\log R=\log R_0+(n-1)(\log T-\log T_0). \qquad (40)$$

Check $$\log \rho=\log \rho_0+\frac{1}{k}(\log P-\log P_0). \qquad (41)$$

Take the auxiliary values

a_0 = adiabatic gradient = -9.8695 for *dry air*.

$$k=1.40624$$
$$\log k=0.44806.$$

$$\log a_0 = 0.99429.$$

$$\log \frac{k}{k-1} = 0.53927$$

$$\log \frac{1}{k-1} = 0.39121$$

$$\log g_0 \rho_m = 5.12489$$

$$g_0 = 9.8060 \text{ meters.}$$

$$\rho = 13595.8 \text{ kilograms.}$$

$$P_0 = g_0 \rho_m B_n.$$

In computing the corresponding velocities in meters per second we used

$$v = \frac{\operatorname{cosec} \varphi}{0.05646} \Delta B \frac{T}{B} \tag{15}$$

for which compare the Monthly Weather Review, June, 1902, and especially formula (15), Monthly Weather Review, October, 1906, page 470.

Table 1. The temperature distribution.—The assumed temperature distribution upon which the computation depends is the result of the direct observations of the temperature in different places, and the known movements of the air in different latitudes and altitudes. These are so fully understood by students that it is not necessary to review the sources of our information. It shows generally a concentration of the isotherms in the lower levels of the Tropics, practically an adiabatic distribution up to 4000 meters, caused by the cooling of the air masses by rapid rising and expansion. They are nearly flat as required for the region of the doldrums, where the horizontal circulation is small. Above 4000 meters the isotherms expand, where the vertical motion is slow and is being converted into a horizontal motion toward the poles. Above 10000 meters height, the isotherms again concentrate, especially on approaching the warmer isothermal layer, not here indicated. In order to avoid an overlapping of the isotherms it has been assumed that a small temperature fall of 0.5° C. per 1000 meters still persists in the upper levels, which is doubtless the fact under some conditions. From latitude 20° to 40° the isotherms rise in altitude, in the higher levels more to the north than in the lower levels. This rise in the isotherms is the cause of the westward movement, which is the component of the trade winds. The temperature gradients are more uniform in all strata, and are so maintained because the air does not rise or fall notably in the high pressure belt, though the downward movement begins there to prevail. The air of the Tropics that passes out in the upper levels appar-

ently falls back to the earth for the larger part in the high pressure belt and not in much higher latitudes, as has been commonly thought. To the north of latitude 40° the isotherms fall very rapidly to earth, especially in the upper levels, where the slope is steep toward the north. This slope of the isotherms is the immediate cause of the prevailing eastward drift in the Temperate Zone, increasing in velocity upward from the surface with the increased slope of the temperature surfaces. The function of the eastward drift seems to be to retain the heated tropical masses within 50° of the equator, otherwise, in order to preserve a constant sum for the momenta of rotation for the whole atmosphere, the eastward movement over small areas in the Temperate Zone must become excessive to counterbalance the westward movement over broad areas in the Tropics at a large distance from the axis of rotation. In the levels 4000 to 10000 meters, in latitudes 50° to 70°, the isotherms are closed up nearly to an adiabatic distance, due partly to descending air, but chiefly to southward crowding in the eastward movement. A similar close position of the isotherms will be inferred in still lower levels (between the surface and 4000 meters and between latitudes 70° and 90°), though this is less certain. It seems, then, that in passing from the equator northward, the isotherms slope upward to the high pressure belt and the wind movement is westward, but beyond the high pressure belt the isotherms descend rapidly with an eastward movement of the atmosphere. The relative cooling of the air in the Tropics is due to rapid ascension, and the heated air masses are retained in and near the Tropics by the rapid eastward drift. In case this distribution of the heat contents of the atmosphere is changed, leakage currents will be formed, which tend to restore this thermal equilibrium through irregular circulations, forming centers of action and local cyclonic and anticyclonic circulations. The computation has been extended to latitude 115° to cover the case when the sun is 23° south of the equator, though modifications occur throughout.

Table 2, the computed pressure P, in gravitation units, and Table 3, the computed barometric pressure B in meters of mercury, are correlatives, being connected by the formula, $P = g_o \rho_m B$. The former is useful for dynamic computations; the latter is commonly used in practise, and is here employed in computing the velocity of motion v eastward or westward. In the direction from the equator to either pole an increase in T means a decrease in pressure, $-\Delta B$, and a westward movement of the wind, as in the Tropics; a decrease in T, means an increase in pressure, $+\Delta B$, and an eastward movement of the wind, as in the temperate zones. The computation of ΔB is made by sub-

tracting the pressure at any latitude from that at a more southerly latitude. Accordingly, on a given level in the atmosphere the pressures increase from the equator to a certain latitude, such as 30°, 35°, 45°, and then fall off toward the pole. If there is any westward wind at any level of the Arctic Zone it means an increase of temperature towards the north at that elevation, and this can be produced only by an adiabatic heating of the descending air. Such a closing up of the isotherms seems general throughout the Temperate Zone, but the observations in the Arctic Zone are so insufficient that this question remains open for research. Generally, in the upper levels the pressure decreases from the equator to the pole, while in the middle and lower levels it increases to the latitude of the high pressure belt and then decreases toward the pole.

Table 4 contains the differences of the barometric pressures in millimeters for each successive 5° interval in latitude, and these values are inserted in the formula (15) for the computation of velocities.

Table 5 contains the computed densities of the air in kilograms per cubic meter, as determined by the assumed prevailing temperature and pressure. It will be noted that in the lower levels these densities increase from the equator toward the pole, from 1.1778 to 1.4320 on the sea level; from 0.7569 to 0.8400 on the 5000-meter level and from 0.4581 to 0.4621 on the 10000-meter level, passing through 0.4821 at the latitude 45°. At higher elevations the density is about constant at the same level over the Tropics and then falls to the poles, being an inversion relatively to the march of density in the lower level. The surfaces of equal density in the upper levels seem to conform closely to the locus of the so-called "isothermal level," of 13000 meters in the Tropics and temperate and polar zones. In consequence of our uncertain knowledge regarding the actual temperatures in this isothermal layer in all latitudes, it may be proper to infer that *the isothermal layer marks off the layer of equal density for the 13000-meter level in all latitudes*, this being the final result of the absorption of the short wave lengths of the incoming radiation, and the reaction of the circulation set up in the lower levels by the absorption of more rays of longer wave length, together with the absorption of the outgoing radiation. The outer layers of the atmosphere may have the *same density* at the *same elevation*, while the lower layers are maintained at *different densities* on the same level by the complex internal circulation induced by the heat energy, which, under the force of gravitation, is seeking to maintain normal equilibrium, namely, the same density in all levels, though continuously disturbed by the absorption of the solar radiations.

THE WIND VELOCITIES AND THE CONSERVATION OF MOMENTA.

Table 6 contains the resulting wind velocities for all latitudes and levels, in a due east or west direction, that would be required to conserve the assumed distribution of the temperatures and pressures under the action of gravity on the rotating earth. Any condition which changes the temperature locally will change the dependent wind velocity and direction, and the resulting wind circulation will become complex. In order that the angular velocity of the rotating earth be kept constant, as indicated by the astronomical observations to be the fact, it would seem necessary that the momenta of rotation for the atmosphere as a whole must on summation be a constant under all circumstances.

Since we have computed the densities at numerous points in the atmosphere, it is easy to compute approximately the air masses, at certain distances from the axis of rotation of the earth, and the angular velocities of these moving masses, so that the summation or integration of the momenta of inertia or the momenta of energy can be computed, at least approximately. The above computed velocities conform closely to those observed in the atmosphere, and by a series of trial computations a true balanced system of temperatures, pressures, densities, and velocities, can be discovered for the earth's atmosphere. This work will be done on some future occasion.

THE FORMATION OF THE "CENTERS OF ACTION" BY LEAKAGE CURRENTS.

The diagram of temperatures, fig. 1, is constructed from the data of Table 1 for the annual mean temperatures of the Northern Hemisphere, and this implies that the sun is standing over the equator, but the irregularities produced by the land and water masses are now smoothed out. If we consider the system of conditions existing in nature as in Table 1, the mean system of temperatures in this diagram will be broken up more or less. Over the ocean, in the Tropics, the temperatures in the lower levels will be depressed, this circumstance will increase the temperature and barometric gradients from the high pressure belt southward and the trade winds will be strengthened. If for any reason the system of the assumed isotherms is depressed, in an east to west direction, then the westward winds will receive a northward component, or the eastward winds a southward component. The result would be to disturb the normal system by a series of "leakage currents" in the lower levels, and this would be indicated by the formation of "centers of action," over the oceans or over the lands respectively, together with southerly winds which feed the cyclones from the south, or northerly winds which feed the anticyclones from the north. These counter cur-

rents in the temperate zones mark the degradation of the primary general circulation into many minor irregular circulations.

If a second system of temperatures, similar to that of fig. 1, be superposed upon that one, at right angles to it, or with any desired angle between the axes, then by composition there can be found any required systems of temperature, pressure, density, and wind vectors that will conform to the one that is observed to exist in any region.

(*To be continued.*)

TABLE 1.—*The adopted observed temperature, T, of the atmosphere*

H / φ	115°	110°	105°	100°	95°	90°	85°	80°	75°	70°	65°	60°
Meters.	°	°	°	°	°	°	°	°	°	°	°	°
16000	180.0	181.0	183.0	185.5	186.5	187.0	188.0	190.0	192.0	194.5	197.5	199.0
15000	180.2	181.2	183.2	185.7	186.7	187.2	188.2	190.2	192.2	194.7	197.7	199.2
14000	180.5	181.5	183.5	186.0	187.0	187.5	188.5	190.5	192.5	195.0	198.0	199.5
13000	181.0	182.0	184.0	186.5	187.5	188.0	189.0	191.0	193.0	195.5	198.5	200.0
12000	183.5	184.5	186.5	188.5	189.5	190.5	191.5	193.5	195.5	198.0	201.0	202.5
11000	186.0	187.0	189.0	191.0	192.0	193.0	194.0	196.0	198.0	200.5	203.5	205.5
10000	188.5	189.5	191.5	193.5	194.5	195.5	196.5	198.5	201.0	203.0	206.0	208.0
9000	191.0	192.0	194.0	196.0	197.0	198.0	199.5	201.0	204.0	205.5	208.5	210.0
8000	193.5	194.5	196.5	199.0	200.0	201.5	203.0	204.0	206.5	208.5	211.0	217.5
7000	196.0	197.0	199.0	202.0	203.5	205.0	206.0	207.0	209.0	212.0	217.0	225.0
6000	199.0	200.0	202.0	205.0	207.0	208.5	209.0	210.0	213.0	218.0	224.0	232.5
5000	203.0	204.0	206.0	208.0	210.0	212.5	214.0	216.0	219.5	225.0	231.0	239.5
4000	208.0	209.0	211.0	213.0	215.0	218.0	220.0	223.0	226.0	232.0	238.0	246.5
3000	213.0	214.0	216.0	218.5	221.0	224.0	227.0	230.0	233.0	239.0	245.5	253.0
2000	218.0	219.0	221.0	224.5	227.5	230.5	234.0	238.0	241.5	247.0	253.0	259.5
1000	223.0	225.5	228.0	232.0	235.5	238.5	242.0	247.0	250.0	255.0	261.0	266.0
0	230.0	233.0	236.0	240.0	244.0	247.0	251.0	256.5	259.7	263.1	268.7	272.2

TABLE 2.—*Computed pressure, P, in gravitation*

Meters.												
16000	6238	6339	6509	6738	6892	7008	7162	7348	7580	7882	8272	8671
15000	7535	7657	7862	8106	8260	8430	8582	8806	9048	9409	9835	10309
14000	9124	9248	9471	9739	9924	10103	10284	10525	10814	11186	11694	12225
13000	11020	11152	11402	11707	11911	12124	12324	12592	12918	13342	13881	14511
12000	13293	13439	13711	14045	14279	14521	14750	15042	15403	15873	16473	17199
11000	15990	16151	16446	16815	17079	17357	17608	17929	18324	18836	19499	[illegible]
10000	19192	19366	19683	20087	20383	20695	20975	21317	21747	22318	23045	[illegible]
9000	22976	23163	23498	23943	24272	24620	24925	25296	25740	26376	27176	28237
8000	27447	27644	27931	28459	28827	29213	29541	29942	30402	31114	31977	33125
7000	32715	32918	33268	33748	34143	34553	34911	35358	35840	36603	37514	38655
6000	38885	39103	39450	39914	40330	40768	41160	41653	42137	42907	43802	[illegible]
5000	46097	46309	46647	47096	47511	47949	48370	48898	49346	50060	50897	51579
4000	54428	54644	54948	55398	55800	56199	56619	57134	57532	58136	58883	[illegible]
3000	64022	64216	64482	64902	65264	65593	65975	66442	66769	67214	67819	[illegible]
2000	75024	75192	75399	75730	76005	76232	76516	76889	77110	77362	77784	[illegible]
1000	87586	87694	87789	87956	88092	88192	88328	88522	88610	88640	88844	89064
0	101855	101788	101721	101656	101581	101521	101454	101388	101321	101135	101081	101149

TABLE 3.—*Computed pressure, B, in meters*

Meters.												
16000	.0468	.0476	.0488	.0505	.0517	.0526	.0537	.0551	.0569	.0591	.0621	.0650
15000	.0565	.0574	.0590	.0608	.0620	.0632	.0644	.0661	.0679	.0703	.0738	.0773
14000	.0684	.0694	.0710	.0730	.0744	.0758	.0771	.0789	.0811	.0839	.0877	.0917
13000	.0827	.0836	.0855	.0878	.0893	.0910	.0924	.0945	.0969	.1001	.1041	[illegible]
12000	.0997	.1008	.1028	.1054	.1071	.1089	.1106	.1128	.1155	.1190	.1236	[illegible]
11000	,1199	.1212	.1234	.1261	.1281	.1302	.1321	.1345	.1374	.1413	.1463	.1525
10000	.1440	.1453	.1476	.1507	.1529	.1552	.1573	.1599	.1631	.1674	.1729	.1799
9000	.1723	.1737	.1763	.1796	.1821	.1847	.1870	.1898	.1931	.1978	.2038	.2118
8000	.2059	.2074	.2100	.2135	.2162	.2191	.2216	.2246	.2280	.2334	.2399	.2485
7000	.2454	.2469	.2495	.2531	.2561	.2592	.2619	.2652	.2688	.2746	.2814	[illegible]
6000	.2917	.2933	.2959	.2995	.3025	.3058	.3087	.3124	.3161	.3218	.3285	[illegible]
5000	.3458	.3474	.3499	.3533	.3564	.3597	.3628	.3668	.3701	.3755	.3818	[illegible]
4000	.4083	.4099	.4122	.4155	.4186	.4215	.4247	.4286	.4315	.4361	.4417	.4475
3000	.4802	.4817	.4837	.4868	.4895	.4920	.4949	.4984	.5008	.5041	.5087	.5135
2000	.5628	.5640	.5656	.5680	.5701	.5718	.5739	.5767	.5784	.5803	.5834	[illegible]
1000	.6570	.6578	.6585	.6598	.6608	.6615	.6625	.6640	.6646	.6649	.6664	[illegible]
0	.7640	.7635	.7630	.7625	.7620	.7615	.7610	.7605	.7600	.7586	.7582	[illegible]

on the absolute-centigrade scale, for each latitude, φ, and altitude, H.

H / φ	55°	50°	45°	40°	35°	30°	25°	20°	15°	10°	5°	0°
Meters.	°	°	°	°	°	°	°	°	°	°	°	°
16000.........	201.0	202.2	203.7	204.0	205.0	206.5	208.0	209.5	211.0	212.0	212.5	213.0
15000.........	201.2	202.5	204.0	204.5	205.5	207.0	208.5	210.0	211.5	212.5	212.5	213.5
14000.........	201.5	203.0	204.5	205.5	206.5	208.0	209.5	211.0	212.5	213.5	214.0	214.5
13000.........	202.0	204.0	205.5	207.0	208.0	209.5	211.0	212.5	214.0	215.0	215.5	216.0
12000.........	205.0	207.5	209.5	212.5	215.0	216.5	218.0	219.0	220.0	221.0	221.5	222.0
11000.........	208.0	211.0	216.0	219.0	221.5	223.0	224.0	225.0	226.0	226.5	227.0	227.0
10000.........	212.0	218.0	222.5	225.5	228.0	229.5	230.0	230.5	231.5	231.5	231.5	231.0
9000.........	218.0	225.0	230.0	233.0	234.5	235.0	235.0	235.0	235.5	235.5	235.5	235.0
8000.........	225.0	232.5	237.5	240.0	241.0	241.0	240.5	240.0	240.0	239.5	239.5	239.0
7000.........	233.0	240.0	245.0	247.0	247.5	247.0	246.0	245.5	245.0	244.5	244.5	244.0
6000.........	240.0	246.5	251.5	253.5	254.0	253.0	252.0	251.0	250.5	250.0	250.0	249.5
5000.........	247.0	253.0	257.5	260.5	261.5	260.0	258.0	257.0	256.0	255.5	255.5	255.0
4000.........	253.5	259.0	263.5	267.0	269.0	267.5	265.0	263.0	262.0	261.0	261.0	261.0
3000.........	259.5	264.5	269.0	272.5	275.5	275.0	273.0	271.0	270.0	270.0	270.0	270.0
2000.........	265.0	269.5	273.5	278.0	282.0	283.0	281.0	279.5	279.7	279.8	279.6	279.5
1000.........	270.0	274.0	278.5	283.0	287.0	290.0	290.0	288.8	289.5	289.6	289.3	289.1
0.........	275.3	278.6	282.6	287.0	290.1	293.3	296.7	298.6	299.3	299.4	299.1	298.9

units for each latitude, φ, and altitude, H.

Meters.												
16000.........	9155	9560	9936	10191	10364	10439	10426	10425	10468	10491	10508	10478
15000.........	10844	11336	11752	12040	12245	12314	12299	12278	12309	12318	12336	12330
14000.........	12859	13414	13885	14226	14455	14515	14474	14438	14463	14462	14472	14464
13000.........	15217	15862	16787	17181	17043	17095	17029	16969	16972	16961	16974	16949
12000.........	17997	18727	19340	19760	20032	20070	19971	19879	19866	19838	19845	19811
11000.........	21236	22046	22710	23149	23426	23445	23309	23187	23157	23112	23114	23069
10000.........	24991	25855	26540	26999	27271	27267	27096	26941	26886	26829	26826	26778
9000.........	29293	30165	30867	31337	31614	31591	31385	31202	31122	31056	31052	31009
8000.........	34178	35024	35723	36205	36503	36467	36237	36027	35931	35865	35861	35817
7000.........	39680	40475	41161	41661	41984	41949	41699	41472	41370	41301	41296	41259
6000.........	45844	46580	47234	47756	48107	48090	47830	47589	47487	47420	47414	47386
5000.........	52753	53406	54021	54546	54928	54939	54689	54441	54343	54283	54276	54259
4000.........	60469	61032	61589	62087	62479	62537	62324	62093	62004	61962	61953	61941
3000.........	69084	69544	70020	70474	70832	70934	70760	70567	70499	70470	70460	70447
2000.........	78700	79034	79426	79778	80070	80179	80054	79892	79830	79800	79792	79776
1000.........	89408	89620	89840	90122	90282	90332	90230	90104	90016	89974	89974	89966
0.........	101281	101414	101521	101588	101642	101548	101377	101216	101095	101042	101056	101058

of mercury for each latitude φ and altitude H.

Meters.												
16000.........	.0687	.0717	.0745	.0764	.0777	.0783	.0782	.0782	.0785	.0787	.0788	.0788
15000.........	.0813	.0850	.0882	.0903	.0918	.0924	.0923	.0921	.0923	.0924	.0925	.0925
14000.........	.0965	.1006	.1041	.1067	.1084	.1089	.1086	.1083	.1085	.1085	.1086	.1085
13000.........	.1141	.1190	.1231	.1259	.1278	.1282	.1277	.1273	.1273	.1272	.1273	.1271
12000.........	.1350	.1405	.1451	.1482	.1503	.1505	.1498	.1491	.1490	.1488	.1489	.1486
11000.........	.1595	.1654	.1703	.1736	.1757	.1759	.1748	.1739	.1737	.1734	.1734	.1730
10000.........	.1875	.1939	.1991	.2025	.2043	.2045	.2032	.2021	.2017	.2012	.2012	.2008
9000.........	.2197	.2263	.2315	.2351	.2372	.2370	.2354	.2340	.2334	.2329	.2329	.2325
8000.........	.2564	.2627	.2680	.2716	.2738	.2735	.2718	.2702	.2695	.2690	.2690	.2686
7000.........	.2976	.3036	.3087	.3125	.3149	.3145	.3128	.3110	.3103	.3098	.3098	.3094
6000.........	.3439	.3494	.3543	.3582	.3608	.3607	.3588	.3570	.3562	.3557	.3557	.3554
5000.........	.3957	.4006	.4052	.4091	.4120	.4121	.4102	.4084	.4076	.4072	.4071	.4069
4000.........	.4536	.4578	.4620	.4657	.4686	.4691	.4675	.4658	.4651	.4648	.4647	.4646
3000.........	.5182	.5216	.5252	.5286	.5313	.5321	.5308	.5293	.5288	.5286	.5285	.5284
2000.........	.5903	.5928	.5958	.5984	.6006	.6014	.6005	.5993	.5988	.5986	.5985	.5984
1000.........	.6706	.6722	.6743	.6760	.6772	.6775	.6768	.6758	.6752	.6749	.6749	.6748
0.........	.7597	.7607	.7615	.7620	.7624	.7617	.7604	.7592	.7583	.7579	.7580	.7580

TABLE 4.—*The change of pressure,* ΔB *(in millimeters).*

H / φ	115°	110°	105°	100°	95°	90°	85°	80°	75°	70°	65°	60°
Meters.												
16000	..	+0.8	+1.2	+1.7	+1.2	+0.9	+1.1	+1.4	+1.8	+2.2	+3.0	[illegible]
15000	..	+0.9	+1.6	+1.8	+1.2	+1.2	+1.2	+1.7	+1.8	+2.4	+3.5	+3.5
14000	.	+1.0	+1.6	+2.0	+1.4	+1.4	+1.3	+1.8	+2.2	+2.8	+3.8	+4.0
13000	.	+0.9	+1.9	+2.3	+1.5	+1.7	+1.4	+2.1	+2.4	+3.2	+4.0	+4.7
12000	.	+1.1	+2.0	+2.6	+1.7	+1.8	+1.7	+2.2	+2.7	+3.5	+4.6	[illegible]
11000	.	+1.3	+2.2	+2.7	+2.0	+2.1	+1.9	+2.4	+2.9	+3.9	+5.0	[illegible]
10000	.	+1.3	+2.3	+3.1	+2.2	+2.3	+2.1	+2.6	+3.2	+4.3	+5.5	+7.0
9000	.	+1.4	+2.6	+3.3	+2.5	+2.6	+2.3	+2.8	+3.3	+4.7	+6.0	[illegible]
8000	.	+1.5	+2.6	+3.5	+2.7	+2.9	+2.5	+3.0	+3.4	+5.4	+6.5	[illegible]
7000	..	+1.5	+2.6	+3.6	+3.0	+3.1	+2.7	+3.3	+3.6	+5.8	+6.8	[illegible]
6000	.	+1.6	+2.6	+3.6	+3.0	+3.3	+2.9	+3.7	+3.7	+5.7	+6.7	[illegible]
5000	.	+1.6	+2.5	+3.4	+3.1	+3.3	+3.1	+4.0	+3.3	+5.4	+6.3	+7.3
4000	.	+1.6	+2.3	+3.3	+3.1	+2.9	+3.2	+3.9	+2.9	+4.6	+5.6	[illegible]
3000	..	+1.5	+2.0	+3.1	+2.7	+2.5	+2.9	+3.5	+2.4	+3.3	+4.6	[illegible]
2000	...	+1.2	+1.6	+2.4	+2.1	+1.7	+2.1	+2.8	+1.7	+1.9	+3.1	+3.5
1000	..	+0.8	+0.7	+1.3	+1.0	+0.7	+1.0	+1.5	+0.6	+0.3	+1.5	[illegible]
0	...	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−1.4	−0.4	+0.5

TABLE 5.—*Computed gaseous density,* ρ,

Meters.												
16000	0.2117	0.2114	0.2126	0.2142	0.2141	0.2140	0.2138	0.2130	0.2151	0.2182	0.2210	[illegible]
15000	0.2422	0.2418	0.2431	0.2443	0.2435	0.2440	0.2431	0.2423	0.2439	0.2474	0.2500	[illegible]
14000	0.2775	0.2765	0.2775	0.2784	0.2775	0.2775	0.2765	0.2750	0.2769	0.2798	0.2827	[illegible]
13000	0.3173	0.3159	0.3167	0.3173	0.3159	0.3160	0.3145	0.3125	0.3142	0.3172	0.3194	[illegible]
12000	0.3626	0.3607	0.3610	0.3612	0.3594	0.3592	0.3574	0.3546	0.3561	0.3589	0.3607	[illegible]
11000	0.4135	0.4111	0.4109	0.4105	0.4082	0.4078	0.4053	0.4017	0.4029	0.4053	0.4067	[illegible]
10000	0.4708	0.4677	0.4669	0.4658	0.4629	0.4621	0.4590	0.4543	0.4550	0.4573	0.4580	[illegible]
9000	0.5351	0.5312	0.5297	0.5278	0.5241	0.5229	0.5190	0.5131	0.5130	0.5150	0.5150	[illegible]
8000	0.6072	0.6024	0.5999	0.5968	0.5922	0.5905	0.5856	0.5785	0.5775	0.5791	0.5781	[illegible]
7000	0.6880	0.6821	0.6783	0.6737	0.6680	0.6654	0.6595	0.6511	0.6492	0.6501	0.6477	[illegible]
6000	0.7779	0.7708	0.7657	0.7591	0.7520	0.7484	0.7414	0.7316	0.7284	0.7279	0.7231	[illegible]
5000	0.8785	0.8693	0.8626	0.8538	0.8449	0.8400	0.8316	0.8199	0.8149	0.8122	0.8046	[illegible]
4000	0.9880	0.9779	0.9691	0.9583	0.9473	0.9403	0.9301	0.9159	0.9069	0.9033	0.8925	[illegible]
3000	1.1090	1.0968	1.0859	1.0725	1.0589	1.0496	1.0370	1.0197	1.0104	1.0015	0.9868	[illegible]
2000	1.2417	1.2271	1.2136	1.1969	1.1801	1.1680	1.1522	1.1312	1.1194	1.1068	1.0878	[illegible]
1000	1.3859	1.3689	1.3523	1.3314	1.3107	1.2956	1.2761	1.2503	1.2357	1.2193	1.1957	[illegible]
0	1.5428	1.5220	1.5016	1.4757	1.4505	1.4330	1.4050	1.3771	1.3592	1.3392	1.3106	[illegible]

TABLE 6.—*Computed velocities* (v) *of the eastward and westward*

Meters.												
16000	....	+11.5	+16.5	+22.4	+15.4	+11.3	+13.7	+17.4	+22.3	+27.3	+37.3	[illegible]
15000	....	10.7	18.2	19.8	12.9	12.6	12.5	17.6	18.7	25.0	36.7	[illegible]
14000	....	9.9	15.2	18.3	12.5	12.3	11.3	15.6	19.1	24.5	33.5	35.6
13000	....	7.4	15.0	17.6	11.2	12.4	10.2	15.3	17.5	23.6	29.8	[illegible]
12000	....	7.6	13.3	16.7	10.7	11.2	10.5	13.6	16.8	21.9	29.2	[illegible]
11000	....	7.6	12.4	14.7	10.7	11.0	9.9	12.6	15.3	20.9	27.2	[illegible]
10000	....	6.4	10.9	14.3	10.0	10.3	9.3	11.6	14.5	19.7	25.6	33.1
9000	....	5.8	10.5	13.0	9.6	9.9	8.7	10.7	12.8	18.4	24.0	[illegible]
8000	....	5.3	8.9	11.7	8.9	9.4	8.1	9.8	11.3	18.2	22.4	[illegible]
7000	....	4.5	8.4	10.3	8.5	8.7	7.6	9.3	10.3	16.9	20.5	[illegible]
6000	....	4.1	6.5	8.9	7.3	8.0	7.0	8.9	9.1	14.6	17.9	[illegible]
5000	....	3.5	5.4	7.2	6.5	6.9	6.5	8.5	7.2	12.2	14.9	[illegible]
4000	....	3.1	4.3	6.1	5.7	5.3	5.9	7.3	5.6	9.2	11.8	[illegible]
3000	....	2.5	3.3	5.0	4.3	4.0	4.7	5.8	4.1	5.9	8.7	[illegible]
2000	....	1.8	2.3	3.4	3.0	2.4	3.0	4.2	2.6	3.0	5.3	[illegible]
1000	....	1.0	0.9	1.6	1.3	0.9	1.3	2.0	0.8	0.4	2.3	[illegible]
0	....	−0.1	−0.1	−0.1	−0.1	−0.1	−0.1	−0.1	−0.1	−1.8	−0.6	[illegible]

for each successive five degrees of latitude.

H / φ	55°	50°	45°	40°	35°	30°	25°	20°	15°	10°	5°	0°
Meters.												
16000	+3.7	+3.0	+2.8	+1.9	+1.3	+0.6	+0.1	0.0	+0.3	+0.2	+0.1	0.0
15000	+4.0	+3.7	+3.2	+2.1	+1.5	+0.6	−0.1	−0.2	+0.2	+0.1	+0.1	0.0
14000	+4.8	+4.1	+3.5	+2.6	+2.6	+1.7	+0.5	−0.3	−0.3	+0.2	0.0	+0.1
13000	+5.3	+4.9	+4.1	+2.8	+1.9	+0.4	−0.5	−0.4	0.0	−0.1	+0.1	−0.2
12000	+6.0	+5.5	+4.6	+3.1	+2.1	+0.2	−0.7	−0.7	−0.1	−0.2	+0.1	−0.3
11000	+7.0	+5.9	+4.9	+3.3	+2.1	+0.2	−1.1	−0.9	−0.2	−0.3	0.0	−0.4
10000	+7.6	+6.4	+5.2	+3.4	+1.8	+0.2	−1.3	−1.1	−0.4	−0.5	0.0	−0.4
9000	+7.9	+6.6	+5.2	+3.6	+2.1	−0.2	−1.6	−1.4	−0.6	−0.5	0.0	−0.4
8000	+7.9	+6.3	+5.3	+3.6	+2.2	−0.3	−1.7	−1.6	−0.7	−0.5	0.0	−0.4
7000	+7.7	+6.0	+5.1	+3.8	+2.4	−0.4	−1.7	−1.8	−0.7	−0.5	0.0	−0.4
6000	+7.2	+5.5	+4.9	+3.9	+2.6	−0.1	−1.9	−1.8	−0.8	−0.5	0.0	−0.3
5000	+6.6	+4.9	+4.6	+3.9	+2.9	+0.1	−1.9	−1.8	−0.8	−0.4	−0.1	−0.2
4000	+5.7	+4.2	+4.2	+3.7	+2.9	+0.5	−1.6	−1.7	−0.7	−0.3	−0.1	−0.1
3000	+4.7	+3.4	+3.6	+3.4	+2.7	+0.8	−1.3	−1.5	−0.5	−0.2	−0.1	−0.1
2000	+3.5	+2.5	+3.0	+2.6	+2.2	+0.8	−0.9	−1.2	−0.5	−0.2	−0.1	−0.1
1000	+2.4	+1.6	+2.1	+1.7	+1.2	+0.3	−0.7	−1.0	−0.6	−0.3	0.0	−0.1
0	+1.0	+1.0	+0.8	−0.5	+0.4	−0.7	−1.3	−1.2	−0.9	−0.4	+0.1	0.0

of the air (in kilograms per cubic meter).

Meters.												
16000	0.2320	0.2365	0.2397	0.2404	0.2407	0.2393	0.2362	0.2345	0.2346	0.2346	0.2354	0.2355
15000	0.2617	0.2670	0.2701	0.2706	0.2710	0.2691	0.2656	0.2635	0.2653	0.2633	0.2638	0.2639
14000	0.2954	0.3009	0.3041	0.3047	0.3050	0.3024	0.2982	0.2957	0.2953	0.2951	0.2955	0.2957
13000	0.3330	0.3390	0.3424	0.3428	0.3428	0.3398	0.3348	0.3317	0.3308	0.3305	0.3310	0.3309
12000	0.3752	0.3815	0.3849	0.3849	0.3846	0.3808	0.3750	0.3712	0.3700	0.3695	0.3699	0.3697
11000	0.4220	0.4284	0.4315	0.4308	0.4299	0.4253	0.4185	0.4141	0.4126	0.4119	0.4123	0.4120
10000	0.4738	0.4799	0.4821	0.4806	0.4789	0.4736	0.4658	0.4607	0.4588	0.4579	0.4584	0.4581
9000	0.5305	0.5355	0.5367	0.5343	0.5320	0.5258	0.5171	0.5114	0.5091	0.5082	0.5086	0.5085
8000	0.5920	0.5955	0.5955	0.5921	0.5893	0.5823	0.5741	0.5665	0.5639	0.5629	0.5634	0.5634
7000	0.6583	0.6600	9.6586	0.6541	0.6509	0.6433	0.6329	0.6262	0.6234	0.6224	0.6229	0.6230
6000	0.7295	0.7293	0.7263	0.7209	0.7171	0.7089	0.6978	0.6905	0.6876	0.6866	0.6872	0.6874
5000	0.8060	0.8038	0.7991	0.7924	0.7880	0.7793	0.7675	0.7598	0.7568	0.7559	0.7566	0.7569
4000	0.8882	0.8838	0.8772	0.8688	0.8636	0.8545	0.8423	0.8343	0.8312	0.8304	0.8312	0.8316
3000	0.9765	0.9698	0.9610	0.9508	0.9442	0.9346	0.9218	0.9138	0.9107	0.9100	0.9108	0.9113
2000	1.0713	1.0622	1.0511	1.0384	1.0302	1.0197	1.0064	0.9981	0.9948	0 9941	0 9950	0.9956
1000	1.1720	1.1615	1.1476	1.1325	1.1220	1.1990	1.0958	1.0872	1.0835	1.0826	1.0838	1.0844
0	1.2817	1.2682	1.2516	1.2332	1.2206	1.2062	1.1904	1.1809	1.1768	1.1758	1.1769	1.1778

motions (in meters per second) required to preserve the pressures, B.

Meters.												
16000	+46.8	+39.1	+38.3	+27.9	+21.2	+11.2	− 2.2	0.0	+11.0	+11.0	+11.0	....
15000	42.8	40.7	37.1	26.2	20.7	9.5	− 1.9	− 4.7	6.3	+ 4.7	9.4	....
14000	43.4	38.3	34.4	27.6	20.0	6.8	− 4.9	− 6.0	+ 5.4	0.0	8.0	....
13000	40.6	38.8	34.3	25.4	19.1	4.6	− 6.9	− 6.9	0.0	− 3.4	6.9	....
12000	39.4	37.6	33.3	23.0	18.6	2.0	− 8.5	−10.6	− 2.0	− 6.1	+ 6.0	....
11000	39.5	34.8	31.1	22.9	16.4	1.8	−11.8	−12.1	− 3.6	− 8.0	0.0	....
10000	37.2	33.3	29.1	20.9	12.4	+ 1.6	−12.3	−13.0	− 6.3	−11.7	0.0	....
9000	33.9	30.4	25.9	19.7	12.8	− 1.4	−13.4	−14.6	− 8.3	−10.3	0.0	....
8000	30.0	25.8	23.5	17.5	11.9	− 1.9	−12.6	−14.7	− 8.5	− 9.1	0.0	....
7000	26.1	21.9	20.3	16.6	11.6	− 2.2	−11.2	−14.7	− 7.6	− 8.1	0.0	....
6000	21.7	17.9	17.4	15.2	11.3	− 0.5	−11.2	−13.1	− 7.7	− 7.2	0.0	....
5000	17.8	14.3	14.6	13.7	11.4	− 0.4	−10.0	−11.7	− 6.9	− 5.1	− 2.6	....
4000	13.8	11.0	12.0	11.7	10.3	+ 2.0	− 7.6	− 9.9	− 5.4	− 3.4	− 2.3	....
3000	10.2	8.0	9.0	9.7	8.6	+ 2.9	− 5.6	− 8.0	− 3.5	− 2.1	− 2.1	....
2000	6.8	5.3	6.9	6.7	6.4	+ 2.7	− 3.5	− 5.8	− 3.2	− 1.9	− 1.9	....
1000	4.2	3.0	4.3	3.9	3.1	+ 0.9	− 2.5	− 4.4	− 3.5	− 2.6	0.0	....
0	+ 1.6	+ 1.7	+ 1.5	− 1.0	+ 0.9	− 1.9	− 4.3	− 4.9	− 4.9	− 3.2	+ 1.6	....

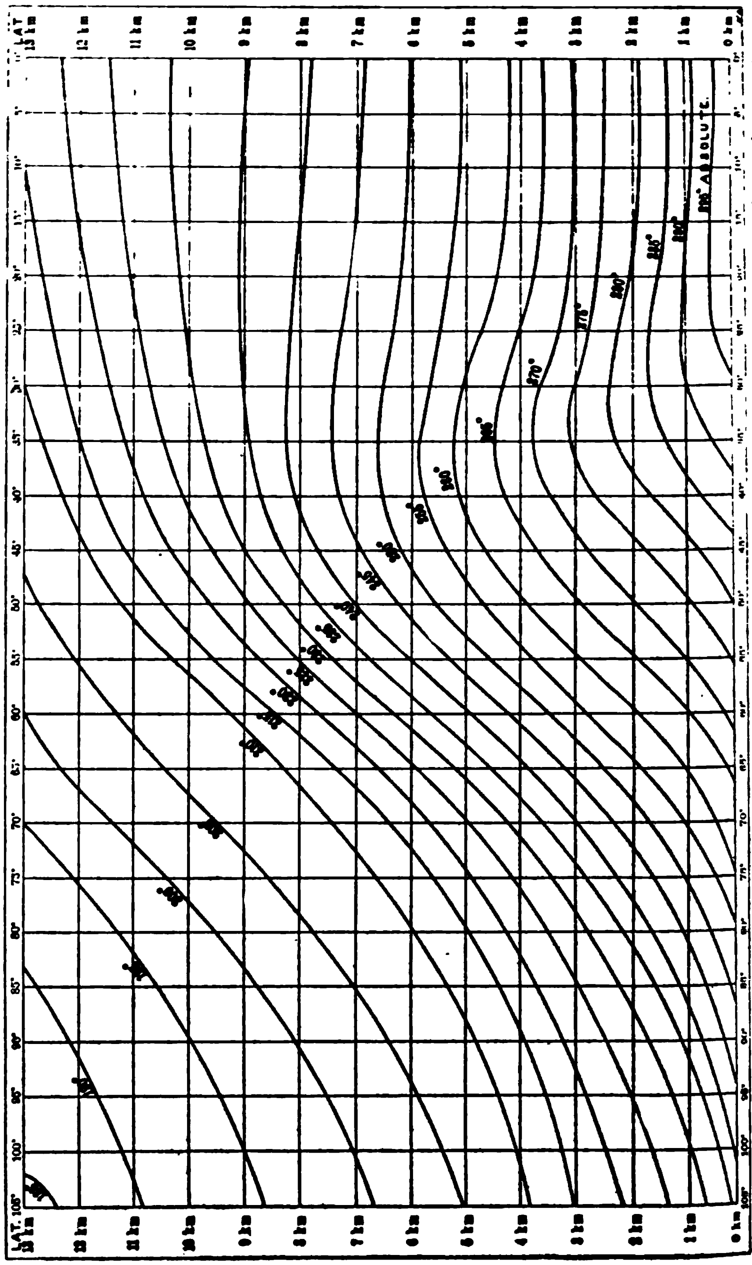

FIG. 1.- Diagram of the assumed distribution of temperature in the earth's atmosphere, when the sun is on the equator.

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(VII) THE ARGENTINE METEOROLOGICAL STATION IN THE SOUTH ORKNEY ISLANDS.

By Vice-Consul-General CHARLES LYON CHANDLER. (Dated Buenos Aires, January 7, 1910, and officially communicated by the Department of State, U. S. A.

The meteorological station of the Argentine Government at Omond House, Laurie Island, (Scotia Bay), in the South Orkney group of islands—the southernmost permanently inhabited spot in the entire world, situated in 60° 44′ south latitude, and 44° 39′ west longitude—was founded by the Scottish Antarctic Expedition, headed by Dr. W. S. Bruce, on the 25th of March, 1903 and was taken over by the Argentine Government on the 21st of February, 1904, since which date it has been administered by the Argentine Ministry of Agriculture, which maintains a staff of four men—three observers and a cook—at this isolated place, the nearest inhabited place to the South Pole The South Orkneys are a group of over 12 rocky and practically barren islands, situated between 60° and 61° south latitude and 43° 3′ and 47° west longitude. They lie about 600 miles southeast by east from the Falkland Islands, and about 500 miles southwest of South Georgia. Although Powell discovered them in 1821, and Weddell visited them in 1823, Dumont d'Urville in 1838, and Larsen in 1893, these islands remained practically unknown until the return of Doctor Bruce's Scottish Antarctic Expedition in 1904. The chief islands are Laurie and Coronation Islands; the former is 12 miles long, 6 miles broad, and 30 square miles in area. Many of the islands have not been thoroughly surveyed. The interior of Laurie Island is lofty, several of the summits being from 2000 to 3000 feet high. A number of deep bays run inland from north to south, separated by narrow rocky peninsulas or high mountain ranges, all the valleys being choked by glaciers; there is very little level ground. There is little soil save some vegetable mold found in some parts of the islands, from 6 to 10 inches deep. The lichens (mostly species of Usnea), with several kinds of moss, form the only terrestrial flora of the island.

The interior dimensions of Omond House, the home of the staff from 1903 to February, 1906, are 14 feet 6 inches square and 9 feet high; there are 2 windows and a door; the walls are solidly built of stone, being 4 feet thick at their thinnest part. It accomodates 6 people. A new, and much more commodious, solidly built wooden house was sent out by the Argentine Government and erected in February, 1906, where the staff now live. The climate is very healthy and all the men keep well. The

cold Antarctic current, carrying as it does streams of ice and icebergs to a latitude corresponding to that of the northern part of England, is one of the principal factors that renders the climate of the South Orkneys, in spite of their low altitude, essentially polar. The mean annual temperature of the islands is 23.8° F. The snowfall is excessive, the sunshine very deficient, and strong gales are frequent. Since observations were begun in March, 1903, the warmest month has been February, 1907, with an average temperature of 34.5° F., and the coldest month August, 1907, with an average temperature of 2.0° F. The date at which Scotia Bay freezes over is irregular, but has been steadily growing later each year since 1903. In 1903 it froze on March 30; in 1904, on May 8; in 1905, on May 17; in 1906, on May 25; in 1907, on June 6; and in 1908, the last year for which observations have arrived at Buenos Aires, on July 7. During 1908 Scotia Bay was frozen for the shortest number of days thus far on record—from May 7 to August 27. The latest date of the ice breaking up is January 18, 1908. This seems to indicate a periodicity in the amount of ice formed in the Antarctic.

The aims of the station are to scientifically and accurately predict the climatic conditions about to prevail in the Argentine Republic, and to extend the world's knowledge of meteorology and the allied sciences, by coordinating observations on the mainland of South America with those in more southerly latitudes. The importance of the station is apparent when we consider that weather changes have a most marked bearing on a country such as the Argentine Republic, whose greatest sources of economic strength are at present and will for some years to come continue to be agricultural and pastoral.

Since the new wooden dwelling house was set up in February, 1906, Omond House has been used for a store house. There are, in addition, various sheds on Laurie Island, where the following instruments are in use: An Eschenhagen variometer, a Kew portable magnetometer, a dip circle, and an earth inductor. The meteorological instruments—the barograph, the thermograph, the hygrograph, and the anemograph—furnish a continuous automatic record of the pressure, the temperature, the humidity, and the wind direction and velocity. In addition to the above there is a complete outfit of standard instruments which are read day and night. They are: A standard Fortin barometer; thermometers placed on a louvered screen, and maximum and minimum thermometers, also rain and snow gages, and terrestrial and solar radiation thermometers, and a sunshine recorder, together with a number of instruments for special investigation. Continuous hourly observations are now available for the South Orkneys since March, 1903, and in 1906 a new station was estab-

lished at South Georgia Island, while stations are contemplated on one of the South Sandwich group and at Wandel Island in 65° 4′ south latitude, where the French expeditiom under Doctor Charcot wintered in 1904–5, and south of which it now (January, 1910) is. From the results of observations at these stations a system of rules will be formulated which will enable navigators bound westward around Cape Horn to determine the most favorable course for this dangerous passage. A synchronous weather chart can be drawn for a wide area, extending as far as 65° south latitude, between the meridians of 30° and 80° west.

The results of the observations carried on at Laurie Island show that enormous variations exist in the winter temperatures of the Antarctic regions, for example, variations in temperature of over 20°—from 2° F. to 22.5° F.—have been noted in the mean temperature of the last 6 Augusts at Omond House. The summer temperature has been extremely steady and equable—rarely rising above 37° F. or falling below 25° F.—since the station was founded in 1903. The summer skies at Laurie Island are almost continuously overcast, the winter season being the finest and clearest.

A citizen of the United States, Mr. Walter G. Davis, of Boston, the Director of the Meteorological Service of the Argentine Republic, has brought this service to its present state of excellence, assisted by several graduates of American universities, and by scholars of other nations, chief among whom may be mentioned Mr. Robert C. Mossman, a Scotch gentleman who lived for two years on the South Orkneys. Mr. Mossman's contributions to polar science are well known. I am greatly indebted to him for valuable assistance and advice in the preparation of this report. His article entitled "Meteorology at the South Orkneys and South Georgia in 1908" is published in "The Scottish Geographic Magazine", April, 1909, Vol. XXV, No. 8, pp. 408–413.

It should have been mentioned that communication between the South Orkneys and the outer world is maintained by an Argentine naval vessel, which, leaving Buenos Aires in January to relieve the staff at that lonely outpost, arrives there after a three weeks voyage, in February, and, after a short stay, returns to Buenos Aires, arriving there in March. Stops are sometimes made going and coming at points of interest in the course of this annual journey.

TABLE 1.—*The adopted observed temperature, T, of the atmosphere*

H / φ	115°	110°	105°	100°	95°	90°	85°	80°	75°	70°	65°	60°
Meters.	°	°	°	°	°	°	°	°	°	°	°	°
16000	180.0	181.0	183.0	185.5	186.5	187.0	188.0	190.0	192.0	194.5	197.5	199.0
15000	180.2	181.2	183.2	185.7	186.7	187.2	188.2	190.2	192.2	194.7	197.7	199.2
14000	180.5	181.5	183.5	186.0	187.0	187.5	188.5	190.5	192.5	195.0	198.0	199.5
13000	181.0	182.0	184.0	186.5	187.5	188.0	189.0	191.0	193.0	195.5	198.5	200.0
12000	183.5	184.5	186.5	188.5	189.5	190.5	191.5	193.5	195.5	198.0	201.0	202.5
11000	186.0	187.0	189.0	191.0	192.0	193.0	194.0	196.0	198.0	200.5	203.5	205.5
10000	188.5	189.5	191.5	193.5	194.5	195.5	196.5	198.5	201.0	203.0	206.0	206.0
9000	191.0	192.0	194.0	196.0	197.0	198.0	199.5	201.0	204.0	205.5	208.5	210.0
8000	193.5	194.5	196.5	199.0	200.0	201.5	203.0	204.0	206.5	208.5	211.0	217.5
7000	196.0	197.0	199.0	202.0	203.5	205.0	206.0	207.0	209.0	212.0	217.0	225.0
6000	199.0	200.0	202.0	205.0	207.0	208.5	209.0	210.0	213.0	218.0	224.0	232.5
5000	203.0	204.0	206.0	208.0	210.0	212.5	214.0	216.0	219.5	225.0	231.0	239.5
4000	208.0	209.0	211.0	213.0	215.0	218.0	220.0	223.0	226.0	232.0	238.0	246.5
3000	213.0	214.0	216.0	218.5	221.0	224.0	227.0	230.0	233.0	239.0	245.5	253.0
2000	218.0	219.0	221.0	224.5	227.5	230.5	234.0	238.0	241.5	247.0	253.0	259.5
1000	223.0	225.5	228.0	232.0	235.5	238.5	242.0	247.0	250.0	255.0	261.0	266.0
0	230.0	233.0	236.0	240.0	244.0	247.0	251.0	256.5	259.7	263.1	268.7	272.2

TABLE 2.—*Computed pressure, P, in gravitation*

Meters.												
16000	6238	6339	6509	6738	6892	7008	7162	7348	7580	7882	8272	8671
15000	7535	7657	7862	8106	8260	8430	8582	8806	9048	9409	9835	[illegible]
14000	9124	9248	9471	9739	9924	10103	10284	10525	10814	11186	11694	[illegible]
13000	11020	11152	11402	11707	11911	12124	12324	12592	12918	13342	13881	14511
12000	13293	13439	13711	14045	14279	14521	14750	15042	15403	15873	16473	17199
11000	15990	16151	16446	16815	17079	17357	17608	17929	18324	18836	19499	[illegible]
10000	19192	19366	19683	20087	20383	20695	20975	21317	21747	22318	23045	[illegible]
9000	22976	23163	23498	23943	24272	24620	24925	25296	25740	26376	27176	[illegible]
8000	27447	27644	27931	28459	28827	29213	29541	29942	30402	31114	31977	33135
7000	32715	32918	33268	33748	34143	34553	34911	35358	35840	36603	37514	[illegible]
6000	38885	39103	39450	39914	40330	40768	41160	41653	42137	42907	43802	[illegible]
5000	46097	46309	46647	47096	47511	47949	48370	48898	49346	50060	50897	[illegible]
4000	54428	54644	54948	55398	55800	56199	56619	57134	57532	58136	58883	59709
3000	64022	64216	64482	64902	65264	65593	65975	66442	66769	67214	67819	68459
2000	75024	75192	75399	75730	76005	76232	76516	76889	77110	77362	77784	[illegible]
1000	87586	87694	87789	87956	88092	88192	88328	88522	88610	88640	88844	[illegible]
0	101855	101788	101721	101656	101581	101521	101454	101388	101321	101135	101081	101149

TABLE 3.—*Computed pressure, B, in meters*

Meters.												
16000	.0468	.0476	.0488	.0505	.0517	.0526	.0537	.0551	.0569	.0591	.0621	.0650
15000	.0565	.0574	.0590	.0608	.0620	.0632	.0644	.0661	.0679	.0703	.0738	[illegible]
14000	.0684	.0694	.0710	.0730	.0744	.0758	.0771	.0789	.0811	.0839	.0877	[illegible]
13000	.0827	.0836	.0855	.0878	.0893	.0910	.0924	.0945	.0969	.1001	.1041	[illegible]
12000	.0997	.1008	.1028	.1054	.1071	.1089	.1106	.1128	.1155	.1190	.1236	[illegible]
11000	,1199	.1212	.1234	.1261	.1281	.1302	.1321	.1345	.1374	.1413	.1463	[illegible]
10000	.1440	.1453	.1476	.1507	.1529	.1552	.1573	.1599	.1631	.1674	.1729	[illegible]
9000	.1723	.1737	.1763	.1796	.1821	.1847	.1870	.1898	.1931	.1978	.2038	.2115
8000	.2059	.2074	.2100	.2135	.2162	.2191	.2216	.2246	.2280	.2334	.2399	[illegible]
7000	.2454	.2469	.2495	.2531	.2561	.2592	.2619	.2652	.2688	.2746	.2814	[illegible]
6000	.2917	.2933	.2959	.2995	.3025	.3058	.3087	.3124	.3161	.3218	.3285	[illegible]
5000	.3458	.3474	.3499	.3533	.3564	.3597	.3628	.3668	.3701	.3755	.3818	[illegible]
4000	.4083	.4099	.4122	.4155	.4186	.4215	.4247	.4286	.4315	.4361	.4417	[illegible]
3000	.4802	.4817	.4837	.4868	.4895	.4920	.4949	.4984	.5008	.5041	.5067	[illegible]
2000	.5628	.5640	.5656	.5680	.5701	.5718	.5739	.5767	.5784	.5803	.5834	[illegible]
1000	.6570	.6578	.6585	.6598	.6608	.6615	.6625	.6640	.6646	.6649	.6664	[illegible]
0	.7640	.7635	.7630	.7625	.7620	.7615	.7610	.7605	.7600	.7586	.7582	[illegible]

on the absolute-centigrade scale, for each latitude, φ, and altitude, H.

H / φ	55°	50°	45°	40°	35°	30°	25°	20°	15°	10°	5°	0°
Meters.	°	°	°	°	°	°	°	°	°	°	°	°
16000.........	201.0	202.2	203.7	204.0	205.0	206.5	208.0	209.5	211.0	212.0	212.5	213.0
15000.........	201.2	202.5	204.0	204.5	205.5	207.0	208.5	210.0	211.5	212.5	212.5	213.5
14000.........	201.5	203.0	204.5	205.5	206.5	208.0	209.5	211.0	212.5	213.5	214.0	214.5
13000.........	202.0	204.0	205.5	207.0	208.0	209.5	211.0	212.5	214.0	215.0	215.5	216.0
12000.........	205.0	207.5	209.5	212.5	215.0	216.5	218.0	219.0	220.0	221.0	221.5	222.0
11000.........	208.0	211.0	216.0	219.0	221.5	223.0	224.0	225.0	226.0	226.5	227.0	227.0
10000.........	212.0	218.0	222.5	225.5	228.0	229.5	230.0	230.5	231.5	231.5	231.5	231.0
9000.........	218.0	225.0	230.0	233.0	234.5	235.0	235.0	235.0	235.5	235.5	235.5	235.0
8000.........	225.0	232.5	237.5	240.0	241.0	241.0	240.5	240.0	240.0	239.5	239.5	239.0
7000.........	233.0	240.0	245.0	247.0	247.5	247.0	246.0	245.5	245.0	244.5	244.5	244.0
6000.........	240.0	246.5	251.5	253.5	254.0	253.0	252.0	251.0	250.5	250.0	250.0	249.5
5000.........	247.0	253.0	257.5	260.5	261.5	260.0	258.0	257.0	256.0	255.5	255.5	255.0
4000.........	253.5	259.0	263.5	267.0	269.0	267.5	265.0	263.0	262.0	261.0	261.0	261.0
3000.........	259.5	264.5	269.0	272.5	275.5	275.0	278.0	271.0	270.0	270.0	270.0	270.0
2000.........	265.0	269.5	273.5	278.0	282.0	283.0	281.0	279.5	279.7	279.8	279.6	279.5
1000.........	270.0	274.0	278.5	283.0	287.0	290.0	290.0	288.8	289.5	289.6	289.3	289.1
0.........	275.3	278.6	282.6	287.0	290.1	293.3	296.7	298.6	299.3	299.4	299.1	298.9

units for each latitude, φ, and altitude, H.

Meters.												
16000.........	9155	9560	9936	10191	10364	10439	10426	10425	10468	10491	10508	10478
15000.........	10844	11336	11752	12040	12245	12314	12299	12278	12309	12318	12336	12330
14000.........	12859	13414	13885	14226	14455	14515	14474	14438	14463	14462	14472	14464
13000.........	15217	15862	16787	17181	17043	17095	17029	16969	16972	16961	16974	16949
12000.........	17997	18727	19340	19760	20032	20070	19971	19879	19866	19838	19845	19811
11000.........	21236	22046	22710	23149	23426	23445	23309	23187	23157	23112	23114	23069
10000.........	24991	25855	26540	26999	27271	27267	27096	26941	26886	26829	26826	26778
9000.........	29293	30165	30867	31337	31614	31591	31385	31202	31122	31056	31052	31009
8000.........	34178	35024	35723	36205	36503	36467	36237	36027	35931	35865	35861	35817
7000.........	39680	40475	41161	41661	41984	41949	41699	41472	41370	41301	41296	41259
6000.........	45844	46580	47234	47756	48107	48090	47830	47589	47487	47420	47414	47386
5000.........	52753	53406	54021	54546	54928	54939	54689	54441	54343	54283	54276	54259
4000.........	60469	61032	61589	62087	62479	62537	62324	62093	62004	61962	61953	61941
3000.........	69084	69544	70020	70474	70832	70934	70760	70567	70499	70470	70460	70447
2000.........	78700	79034	79426	79778	80070	80179	80054	79892	79830	79800	79792	79776
1000.........	89408	89620	89840	90122	90282	90332	90230	90104	90016	89974	89974	89966
0.........	101281	101414	101521	101588	101642	101548	101377	101216	101095	101042	101056	101058

of mercury for each latitude φ and altitude H.

Meters.												
16000.........	.0687	.0717	.0745	.0764	.0777	.0783	.0782	.0782	.0785	.0787	.0788	.0788
15000.........	.0813	.0850	.0882	.0903	.0918	.0924	.0923	.0921	.0923	.0924	.0925	.0925
14000.........	.0965	.1006	.1041	.1067	.1084	.1089	.1086	.1083	.1085	.1085	.1086	.1085
13000.........	.1141	.1190	.1231	.1259	.1278	.1282	.1277	.1273	.1273	.1272	.1273	.1271
12000.........	.1350	.1405	.1451	.1482	.1503	.1505	.1498	.1491	.1490	.1488	.1489	.1486
11000.........	.1595	.1654	.1703	.1736	.1757	.1759	.1748	.1739	.1737	.1734	.1734	.1730
10000.........	.1875	.1939	.1991	.2025	.2043	.2045	.2032	.2021	.2017	.2012	.2012	.2008
9000.........	.2197	.2263	.2315	.2351	.2372	.2370	.2354	.2340	.2334	.2329	.2329	.2325
8000.........	.2564	.2627	.2680	.2716	.2738	.2735	.2718	.2702	.2695	.2690	.2690	.2686
7000.........	.2976	.3036	.3087	.3125	.3149	.3145	.3128	.3110	.3103	.3098	.3098	.3094
6000.........	.3439	.3494	.3543	.3582	.3608	.3607	.3588	.3570	.3562	.3557	.3557	.3554
5000.........	.3957	.4006	.4052	.4091	.4120	.4121	.4102	.4084	.4076	.4072	.4071	.4069
4000.........	.4536	.4578	.4620	.4657	.4686	.4691	.4675	.4658	.4651	.4648	.4647	.4646
3000.........	.5182	.5216	.5252	.5286	.5313	.5321	.5308	.5293	.5288	.5286	.5285	.5284
2000.........	.5903	.5928	.5958	.5984	.6006	.6014	.6005	.5993	.5988	.5986	.5985	.5984
1000.........	.6706	.6722	.6743	.6760	.6772	.6775	.6768	.6758	.6752	.6749	.6749	.6748
0.........	.7597	.7607	.7615	.7620	.7624	.7617	.7604	.7592	.7583	.7579	.7580	.7580

TABLE 4.—*The change of pressure, ΔB (in millimeters),*

H / φ	115°	110°	105°	100°	95°	90°	85°	80°	75°	70°	65°	60°
Meters.												
16000	......	+0.8	+1.2	+1.7	+1.2	+0.9	+1.1	+1.4	+1.8	+2.2	+3.0	+2.9
15000	......	+0.9	+1.6	+1.8	+1.2	+1.2	+1.2	+1.7	+1.8	+2.4	+3.5	+3.5
14000	......	+1.0	+1.6	+2.0	+1.4	+1.4	+1.3	+1.8	+2.2	+2.8	+3.8	+4.0
13000	......	+0.9	+1.9	+2.3	+1.5	+1.7	+1.4	+2.1	+2.4	+3.2	+4.0	+4.7
12000	......	+1.1	+2.0	+2.6	+1.7	+1.8	+1.7	+2.2	+2.7	+3.5	+4.6	+5.4
11000	......	+1.3	+2.2	+2.7	+2.0	+2.1	+1.9	+2.4	+2.9	+3.9	+5.0	+6.2
10000	......	+1.3	+2.3	+3.1	+2.2	+2.3	+2.1	+2.6	+3.2	+4.3	+5.5	+7.0
9000	......	+1.4	+2.6	+3.3	+2.5	+2.6	+2.3	+2.8	+3.3	+4.7	+6.0	+8.0
8000	......	+1.5	+2.6	+3.5	+2.7	+2.9	+2.5	+3.0	+3.4	+5.4	+6.5	+8.6
7000	......	+1.5	+2.6	+3.6	+3.0	+3.1	+2.7	+3.3	+3.6	+5.8	+6.8	+8.5
6000	......	+1.6	+2.6	+3.6	+3.0	+3.3	+2.9	+3.7	+3.7	+5.7	+6.7	+8.2
5000	......	+1.6	+2.5	+3.4	+3.1	+3.3	+3.1	+4.0	+3.3	+5.4	+6.3	+7.3
4000	......	+1.6	+2.3	+3.3	+3.1	+2.9	+3.2	+3.9	+2.9	+4.6	+5.6	+6.2
3000	......	+1.5	+2.0	+3.1	+2.7	+2.5	+2.9	+3.5	+2.4	+3.3	+4.6	+4.8
2000	......	+1.2	+1.6	+2.4	+2.1	+1.7	+2.1	+2.8	+1.7	+1.9	+3.1	+3.5
1000	......	+0.8	+0.7	+1.3	+1.0	+0.7	+1.0	+1.5	+0.6	+0.3	+1.5	+1.8
0	......	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−0.5	−1.4	−0.4	+0.5

TABLE 5.—*Computed gaseous density, ρ,*

Meters.												
16000	0.2117	0.2114	0.2126	0.2142	0.2141	0.2140	0.2138	0.2130	0.2151	0.2182	0.2210	0.2164
15000	0.2422	0.2418	0.2431	0.2443	0.2435	0.2440	0.2431	0.2423	0.2439	0.2474	0.2500	0.2552
14000	0.2775	0.2765	0.2775	0.2784	0.2775	0.2775	0.2765	0.2750	0.2769	0.2798	0.2827	0.2881
13000	0.3173	0.3159	0.3167	0.3173	0.3159	0.3160	0.3145	0.3125	0.3142	0.3172	0.3194	0.3254
12000	0.3626	0.3607	0.3610	0.3612	0.3594	0.3592	0.3574	0.3546	0.3561	0.3589	0.3607	0.3672
11000	0.4135	0.4111	0.4109	0.4105	0.4082	0.4078	0.4053	0.4017	0.4029	0.4053	0.4067	0.4136
10000	0.4708	0.4677	0.4669	0.4658	0.4629	0.4621	0.4590	0.4543	0.4550	0.4573	0.4580	0.4652
9000	0.5351	0.5312	0.5297	0.5278	0.5241	0.5229	0.5190	0.5131	0.5130	0.5150	0.5150	0.5225
8000	0.6072	0.6024	0.5999	0.5968	0.5922	0.5905	0.5856	0.5785	0.5775	0.5791	0.5781	0.5853
7000	0.6880	0.6821	0.6783	0.6737	0.6680	0.6654	0.6595	0.6511	0.6492	0.6501	0.6477	0.6532
6000	0.7779	0.7708	0.7657	0.7591	0.7520	0.7484	0.7414	0.7316	0.7284	0.7279	0.7231	0.7264
5000	0.8785	0.8693	0.8626	0.8538	0.8449	0.8400	0.8316	0.8199	0.8149	0.8122	0.8046	0.8053
4000	0.9880	0.9779	0.9691	0.9583	0.9473	0.9403	0.9301	0.9159	0.9089	0.9033	0.8925	0.8899
3000	1.1090	1.0968	1.0859	1.0725	1.0589	1.0496	1.0370	1.0197	1.0104	1.0015	0.9868	0.9807
2000	1.2417	1.2271	1.2136	1.1969	1.1801	1.1680	1.1522	1.1312	1.1194	1.1068	1.0878	1.0784
1000	1.3859	1.3689	1.3523	1.3314	1.3107	1.2956	1.2761	1.2503	1.2357	1.2193	1.1957	1.1828
0	1.5428	1.5220	1.5016	1.4757	1.4505	1.4320	1.4050	1.3771	1.3592	1.3392	1.3106	1.2946

TABLE 6.—*Computed velocities (v) of the eastward and westward*

Meters.												
16000	......	+11.5	+16.5	+22.4	+15.4	+11.3	+13.7	+17.4	+22.3	+27.3	+37.3	+36.2
15000	......	10.7	18.2	19.8	12.9	12.6	12.5	17.6	18.7	25.0	36.7	36.9
14000	......	9.9	15.2	18.3	12.5	12.3	11.3	15.6	19.1	24.5	33.5	35.6
13000	......	7.4	15.0	17.6	11.2	12.4	10.2	15.3	17.5	23.6	29.8	35.3
12000	......	7.6	13.3	16.7	10.7	11.2	10.5	13.6	16.8	21.9	29.2	34.5
11000	......	7.6	12.4	14.7	10.7	11.0	9.9	12.6	15.3	20.9	27.2	34.2
10000	......	6.4	10.9	14.3	10.0	10.3	9.3	11.6	14.5	19.7	25.6	33.1
9000	......	5.8	10.5	13.0	9.6	9.9	8.7	10.7	12.8	18.4	24.0	32.5
8000	......	5.3	8.9	11.7	8.9	9.4	8.1	9.8	11.3	18.2	22.4	30.8
7000	......	4.5	8.4	10.3	8.5	8.7	7.6	9.3	10.3	16.9	20.5	27.0
6000	......	4.1	6.5	8.9	7.3	8.0	7.0	8.9	9.1	14.6	17.9	23.2
5000	......	3.5	5.4	7.2	6.5	6.9	6.5	8.5	7.2	12.2	14.9	18.4
4000	......	3.1	4.3	6.1	5.7	5.3	5.9	7.3	5.6	9.2	11.8	14.0
3000	......	2.5	3.3	5.0	4.3	4.0	4.7	5.8	4.1	5.9	8.7	9.7
2000	......	1.8	2.3	3.4	3.0	2.4	3.0	4.2	2.6	3.0	5.3	6.2
1000	......	1.0	0.9	1.6	1.3	0.9	1.3	2.0	0.8	0.4	2.3	2.9
0	......	−0.1	−0.1	−0.1	−0.1	−0.1	−0.1	−0.1	−0.1	−1.8	−0.6	+ 0.7

for each successive five degrees of latitude.

H / φ	55°	50°	45°	40°	35°	30°	25°	20°	15°	10°	5°	0°
Meters.												
16000	+3.7	+3.0	+2.8	+1.9	+1.3	+0.6	+0.1	0.0	+0.3	+0.2	+0.1	0.0
15000	+4.0	+3.7	+3.2	+2.1	+1.5	+0.6	−0.1	−0.2	+0.2	+0.1	+0.1	0.0
14000	+4.8	+4.1	+3.5	+2.6	+2.6	+1.7	+0.5	−0.3	−0.3	+0.2	0.0	+0.1
13000	+5.3	+4.9	+4.1	+2.8	+1.9	+0.4	−0.5	−0.4	0.0	−0.1	+0.1	−0.2
12000	+6.0	+5.5	+4.6	+3.1	+2.1	+0.2	−0.7	−0.7	−0.1	−0.2	+0.1	−0.3
11000	+7.0	+5.9	+4.9	+3.3	+2.1	+0.2	−1.1	−0.9	−0.2	−0.3	0.0	−0.4
10000	+7.6	+6.4	+5.2	+3.4	+1.8	+0.2	−1.3	−1.1	−0.4	−0.5	0.0	−0.4
9000	+7.9	+6.6	+5.2	+3.6	+2.1	−0.2	−1.6	−1.4	−0.6	−0.5	0.0	−0.4
8000	+7.9	+6.3	+5.3	+3.6	+2.2	−0.3	−1.7	−1.6	−0.7	−0.5	0.0	−0.4
7000	+7.7	+6.0	+5.1	+3.8	+2.4	−0.4	−1.7	−1.8	−0.7	−0.5	0.0	−0.4
6000	+7.2	+5.5	+4.9	+3.9	+2.6	−0.1	−1.9	−1.8	−0.8	−0.5	0.0	−0.3
5000	+6.6	+4.9	+4.6	+3.9	+2.9	+0.1	−1.9	−1.8	−0.8	−0.4	−0.1	−0.2
4000	+5.7	+4.2	+4.2	+3.7	+2.9	+0.5	−1.6	−1.7	−0.7	−0.3	−0.1	−0.1
3000	+4.7	+3.4	+3.6	+3.4	+2.7	+0.8	−1.3	−1.5	−0.5	−0.2	−0.1	−0.1
2000	+3.5	+2.5	+3.0	+2.6	+2.2	+0.8	−0.9	−1.2	−0.5	−0.2	−0.1	−0.1
1000	+2.4	+1.6	+2.1	+1.7	+1.2	+0.3	−0.7	−1.0	−0.6	−0.3	0.0	−0.1
0	+1.0	+1.0	+0.8	−0.5	+0.4	−0.7	−1.3	−1.2	−0.9	−0.4	+0.1	0.0

of the air (in kilograms per cubic meter).

Meters.												
16000	0.2320	0.2365	0.2397	0.2404	0.2407	0.2393	0.2362	0.2345	0.2346	0.2346	0.2354	0.2355
15000	0.2617	0.2670	0.2701	0.2706	0.2710	0.2691	0.2656	0.2635	0.2653	0.2633	0.2638	0.2639
14000	0.2954	0.3009	0.3041	0.3047	0.3050	0.3024	0.2982	0.2957	0.2953	0.2951	0.2955	0.2957
13000	0.3330	0.3390	0.3424	0.3428	0.3428	0.3398	0.3348	0.3317	0.3308	0.3305	0.3310	0.3309
12000	0.3752	0.3815	0.3849	0.3849	0.3846	0.3808	0.3750	0.3712	0.3700	0.3695	0.3699	0.3697
11000	0.4220	0.4284	0.4315	0.4308	0.4299	0.4253	0.4185	0.4141	0.4126	0.4119	0.4123	0.4120
10000	0.4738	0.4799	0.4821	0.4806	0.4789	0.4736	0.4658	0.4607	0.4588	0.4579	0.4584	0.4581
9000	0.5305	0.5355	0.5367	0.5343	0.5320	0.5258	0.5171	0.5114	0.5091	0.5082	0.5086	0.5085
8000	0.5920	0.5955	0.5955	0.5921	0.5893	0.5823	0.5741	0.5665	0.5639	0.5629	0.5634	0.5634
7000	0.6583	0.6600	9.6586	0.6541	0.6509	0.6433	0.6329	0.6262	0.6234	0.6224	0.6229	0.6230
6000	0.7295	0.7293	0.7263	0.7209	0.7171	0.7089	0.6978	0.6905	0.6876	0.6866	0.6872	0.6874
5000	0.8060	0.8038	0.7991	0.7924	0.7880	0.7793	0.7675	0.7598	0.7568	0.7559	0.7566	0.7569
4000	0.8882	0.8838	0.8772	0.8688	0.8636	0.8545	0.8423	0.8343	0.8312	0.8304	0.8312	0.8316
3000	0.9765	0.9698	0.9610	0.9508	0.9442	0.9346	0.9218	0.9138	0.9107	0.9100	0.9108	0.9113
2000	1.0713	1.0622	1.0511	1.0384	1.0302	1.0197	1.0064	0.9981	0.9948	0.9941	0.9950	0.9956
1000	1.1720	1.1615	1.1476	1.1325	1.1220	1.1990	1.0958	1.0872	1.0835	1.0826	1.0838	1.0844
0	1.2817	1.2682	1.2516	1.2332	1.2206	1.2062	1.1904	1.1809	1.1768	1.1758	1.1769	1.1778

motions (in meters per second) required to preserve the pressures, B.

Meters.												
16000	+46.8	+39.1	+38.3	+27.9	+21.2	+11.2	− 2.2	0.0	+11.0	+11.0	+11.0	....
15000	42.8	40.7	37.1	26.2	20.7	9.5	− 1.9	− 4.7	6.3	+ 4.7	9.4	....
14000	43.4	38.3	34.4	27.6	20.0	6.8	− 4.9	− 6.0	+ 5.4	0.0	8.0	....
13000	40.6	38.8	34.3	25.4	19.1	4.6	− 6.9	− 6.9	0.0	− 3.4	6.9	....
12000	39.4	37.6	33.3	23.0	18.6	2.0	− 8.5	−10.6	− 2.0	− 6.1	+ 6.0	....
11000	39.5	34.8	31.1	22.9	16.4	1.8	−11.8	−12.1	− 3.6	− 8.0	0.0	....
10000	37.2	33.3	29.1	20.9	12.4	+ 1.6	−12.3	−13.0	− 6.3	−11.7	0.0	....
9000	33.9	30.4	25.9	19.7	12.8	− 1.4	−13.4	−14.6	− 8.3	−10.3	0.0	....
8000	30.0	25.8	23.5	17.5	11.9	− 1.9	−12.6	−14.7	− 8.5	− 9.1	0.0	....
7000	26.1	21.9	20.3	16.6	11.6	− 2.2	−11.2	−14.7	− 7.6	− 8.1	0.0	....
6000	21.7	17.9	17.4	15.2	11.3	− 0.5	−11.2	−13.1	− 7.7	− 7.2	0.0	....
5000	17.8	14.3	14.6	13.7	11.4	− 0.4	−10.0	−11.7	− 6.9	− 5.1	− 2.6	....
4000	13.8	11.0	12.0	11.7	10.3	+ 2.0	− 7.6	− 9.9	− 5.4	− 3.4	− 2.3	....
3000	10.2	8.0	9.0	9.7	8.6	+ 2.9	− 5.6	− 8.0	− 3.5	− 2.1	− 2.1	....
2000	6.8	5.3	6.9	6.7	6.4	+ 2.7	− 3.5	− 5.8	− 3.2	− 1.9	− 1.9	....
1000	4.2	3.0	4.3	3.9	3.1	+ 0.9	− 2.5	− 4.4	− 3.5	− 2.6	0.0	....
0	+ 1.6	+ 1.7	+ 1.5	− 1.0	+ 0.9	− 1.9	− 4.3	− 4.9	− 4.9	− 3.2	+ 1.6	....

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
April 4.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
9:54 a. m....	719.2	15.4	82	sw.	4.5	526	719.2	15.4	82	sw.	4.5
10:01 a. m....	719.2	15.2	87	w.	4.5	810	695.7	15.5	......	wsw.	....
10:33 a. m....	719.2	12.5	96	w.	4.0	1086	673.1	12.5	......	wsw.	....
10:48 a. m....	719.2	13.0	98	wsw.	4.5	1501	640.8	10.3	......	wsw.	....
11:01 a. m....	719.2	13.3	93	w.	4.5	2016	601.9	5.9	......	w.	....
11:16 a. m....	719.1	14.2	87	w.	4.5	2488	568.3	3.2	......	wsw.	....
11:37 a. m....	719.1	14.2	90	w.	4.5	3286	515.1	−0.5	......	wsw.	....
12:03 p. m....	719.0	15.3	85	w.	4.9	3932	475.3	−3.9	......	w.	....
12:55 p. m....	718.6	18.8	63	sw.	4.5	4473	443.3	−9.2	......	w.	....
2:02 p. m....	718.2	19.7	77	sse.	3.1	3747	486.5	−3.6	......	w.	....
2:22 p. m....	718.1	19.4	74	se.	3.1	3206	520.7	0.3	......	w.	....
2:37 p. m....	718.0	18.8	77	se.	2.2	2641	558.1	5.1	......	w.	....
2:50 p. m....	718.0	19.1	74	se.	2.2	1812	617.1	10.6	......	wsw.	....
2:59 p. m....	717.9	18.7	78	se.	1.8	1171	665.6	14.3	......	sw.	....
3:06 p. m....	717.9	18.4	78	se.	1.8	526	717.9	18.4	78	se.	1.8
April 5.											
7:05 a. m....	716.8	16.6	73	wnw.	8.0	526	716.8	16.6	73	wnw.	8.0
7:13 a. m....	716.8	16.4	75	wnw.	8.5	878	688.2	20.4	......	w.	....
7:25 a. m....	716.8	16.2	75	wnw.	9.4	1368	649.8	16.7	......	w.	....
7:37 a. m....	716.8	16.4	75	wnw.	7.6	1868	612.8	12.1	......	w.	....
7:50 a. m....	716.8	17.0	71	w.	8.5	2429	573.2	8.4	......	w.	....
8:21 a. m....	716.8	17.9	68	wsw.	7.2	3003	535.0	5.8	......	w.	....
8:53 a. m....	716.7	19.7	57	wsw.	4.5	3484	504.4	2.4	......	wsw.	....
9:25 a. m....	716.7	21.2	50	wsw.	4.0	3881	480.2	−0.4	......	wsw.	....
9:59 a. m....	716.7	23.1	42	wsw.	4.0	3544	500.7	1.7	......	wsw.	....
10:18 a. m....	716.6	24.0	36	wsw.	4.0	2896	542.5	6.8	......	wsw.	....
10:36 p. m....	716.5	24.6	32	wsw.	4.0	2368	577.7	9.1	......	wsw.	....
10:44 a. m....	716.4	24.8	33	wsw.	4.0	1634	630.2	14.6	......	wsw.	....
10:50 a. m....	716.3	25.0	32	wsw.	4.0	1224	661.1	18.3	......	w.	....
10:59 a. m....	716.3	25.4	35	wsw.	2.2	792	695.0	22.3	......	w.	....
11:03 a. m....	716.3	24.4	59	se.	1.8	526	716.3	24.4	59	se.	1.8

April 4.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 8000 m.; at maximum altitude, 7600 m.

There were 6/10 A.-Cu. and 3/10 St. from the west; the St. covered the sky by 10:08 a. m. and light rain began. The rain ended 11:10 a. m. and the St. were gradually followed by St.-Cu. After 1:15 p. m., 4/10 to 7/10 Ci.-St. and 1/10 to 2/10 A.-Cu. from the west were present. The head kite was in the clouds at intervals from 11:30 a. m. to 12:37 p. m.

Low pressure was central over Minnesota. High pressure, central off the coast of New England, extended southward to Florida.

April 5.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 7400 m.; at maximum altitude, 6600 m.

Ci. from the west decreased from 5/10 at 7 a. m. to none by 11 a. m. There was a light haze.

At 8 a. m. a low was central over Illinois, with secondary depression over Lake Superior.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910											
April 6.	*mm.*	*°C.*	*%*		*m. p. s.*	*m.*	*mm.*	*°C.*	*%*		*m. p. s.*
7:09 a. m....	709.5	15.4	74	sw.	7.6	526	709.5	15.4	74	sw.	7.6
7:20 a. m....	709.6	16.2	70	sw.	6.3	964	674.0	14.5	......	sw.	....
7:35 a. m....	709.6	16.2	70	w.	7.6	1525	630.1	8.6	......	sw.	....
7:45 a. m....	709.7	16.2	68	wnw.	6.3	1736	614.4	8.6	......	sw.	....
7:53 a. m....	709.7	15.8	67	wnw.	5.8	1996	595.2	6.6	......	ssw.	....
8:08 a. m....	709.7	16.0	67	wnw.	7.2	2534	557.5	5.6	......	ssw.	....
8:20 a. m....	709.6	15.7	68	nw.	5.8	2951	529.6	2.1	......	ssw.	....
8:37 a. m....	709.5	16.0	65	nw.	5.8	3286	508.0	−0.9	......	ssw.	....
9:35 a. m....	709.3	17.2	62	nw.	2.7	3534	492.4	−1.9	......	ssw.	....
9:54 a. m....	709.3	17.7	60	nw.	2.7	2897	533.3	1.2	......	ssw.	....
10:21 a. m....	709.1	17.5	59	wsw.	3.6	1945	598.8	6.1	......	ssw.	....
12:30 p. m....	707.6	21.3	31	sse.	5.8	1853	604.8	6.8	......	sw.	....
12:38 a. m....	707.5	21.2	32	sse.	6.3	1510	630.1	9.7	......	sw.	....
12:44 p. m....	707.4	20.9	35	sse.	4.9	1384	639.6	11.6	......	ssw.	....
12:57 p. m....	707.2	20.4	43	ssw.	3.6	526	707.2	20.4	43	ssw.	3.6
April 7.											
1:36 p. m....	710.7	2.8	60	nw.	17.9	526	710.7	2.8	60	nw.	17.9
1:40 p. m....	710.7	2.8	60	nw.	19.7	859	681.9	−1.0	......	nw.	....
2:20 p. m....	710.7	2.9	63	wnw.	15.6	1210	652.3	−4.4	......	nw.	....
2:38 p. m....	710.8	2.8	62	nw.	18.8	1469	631.3	−6.3	......	nw.	....
2:57 p. m....	710.8	2.6	62	nw.	20.6	1165	656.0	−4.7	......	nw.	....
3:22 p. m....	710.8	3.2	60	nw.	21.5	526	710.8	3.2	60	nw.	21.5
April 8.											
11:35 a. m....	715.9	7.8	31	nw.	13.4	526	715.9	7.8	31	nw.	13.4
11:40 a. m....	715.9	7.8	30	wnw.	13.4	890	685.0	3.2	......	wnw.	....
11:55 a. m....	715.8	8.7	31	wnw.	14.3	1309	650.2	1.5	......	nw.	....
12:03 p. m....	715.8	8.8	29	wnw.	14.3	1806	611.4	2.7	......	nw.	....
12:13 p. m....	715.7	9.3	28	wnw.	14.3	2260	578.1	0.4	......	nnw.	....
12:17 p. m....	715.7	9.7	28	wnw.	14.3	2723	545.7	2.3	......	nw.	....
12:35 p. m....	715.6	10.0	27	wnw.	16.1	3347	504.8	− 2.6	......	nw.	....
12:54 p. m....	715.4	10.6	28	nw.	17.9	3924	469.0	− 7.3	......	nw.	....
1:16 p. m....	715.3	10.6	22	wnw.	16.1	4487	436.0	−10.6	......	nw.	....
3:31 p. m....	714.7	13.0	15	nw.	17.9	3543	493.6	− 3.6	......	nw.	....
4:09 p. m....	714.8	13.4	16	nw.	14.3	2976	529.8	1.0	......	nw.	....
5:09 p. m....	715.1	13.0	17	nw.	14.3	1896	605.3	5.5	......	nw.	....
5:23 p. m....	715.2	12.6	18	nw.	14.3	1594	628.3	3.0	......	wnw.	....
5:33 p. m....	715.2	12.1	20	nw.	14.3	1291	652.0	4.4	......	wnw.	....
5:45 p. m....	715.3	11.8	22	nw.	14.3	844	688.6	8.2	......	wnw.	....
5:50 p. m....	715.3	11.8	22	nw.	14.3	526	715.3	11.8	22	nw.	14.3

April 6.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 7500 m.; at maximum altitude, 6700 m.

There were 4/10 to 9/10 clouds consisting of St.-Cu. and A.-Cu., both from the southwest. The head kite was above the St.-Cu. level from 7:45 a. m. to 12:17 p. m.

Pressure was low over Ontario and high over Oklahoma.

April 7.—One kite was used; lifting surface, 5.4 sq. m. Wire out, 2500 m.; at maximum altitude, 2250 m.

St.-Cu., from the northwest, nearly covered the sky. The head kite was in St.-Cu. at intervals from 2:32 until 2:51 p. m.

Low pressure was central over Maine. A ridge of high pressure covered the Mississippi Valley.

April 8.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 9000 m., at maximum altitude.

The sky was cloudless until 4:12 p. m., when a few Ci.-St. from the northwest appeared, and increased gradually to 6/10 by the end of the flight.

Low pressure was central off the coast of Maine and pressure was high over the Ohio Valley.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
April 9.	*mm.*	*° C.*	*%*		*m. p. s.*	*m.*	*mm.*	*° C.*	*%*		*m. p. s.*
7:13 a. m....	715.4	10.6	33	wnw.	9.8	526	715.4	10.6	33	wnw.	9.8
7:20 a. m....	715.3	10.6	33	w.	8.9	870	686.4	9.6	......	w.	....
7:29 a. m....	715.3	10.7	33	w.	9.4	1252	655.4	8.0	......	wnw.	....
7:46 a. m....	715.2	11.3	33	w.	9.8	1886	606.7	4.8	......	wnw.	....
7:57 a. m....	715.2	11.6	33	w.	9.4	2284	577.8	2.5	......	wnw.	....
8:13 a. m....	715.1	12.4	33	w.	9.4	2818	540.7	− 1.0	......	wnw.	....
8:37 a. m....	715.0	13.6	32	w.	10.3	3457	498.9	− 5.7	......	wnw.	....
9:17 a. m....	714.7	14.6	30	w.	8.9	4131	457.5	−10.6	......	wnw.	....
9:48 a. m....	714.4	14.8	30	w.	11.2	3696	484.0	− 7.0	......	wnw.	....
10:13 a. m....	714.1	14.9	30	w.	10.7	3211	514.5	− 4.0	......	wnw.	....
10:53 a. m....	713.5	17.0	33	w.	12.5	2850	538.8	− 0.5	......	wnw.	....
11:12 a. m....	713.3	17.9	32	w.	14.8	2459	565.8	2.9	......	w.	....
11:56 a. m....	712.8	19.4	29	w.	16.1	1907	604.9	5.5	......	w.	....
12:11 p. m....	712.6	19.8	33	w.	14.3	1281	652.0	11.0	......	w.	....
12:34 p. m....	712.2	20.6	32	w.	15.6	526	712.2	20.6	32	w.	15.6
April 10.											
6:54 a. m....	716.6	6.0	37	wnw.	8.0	526	716.6	6.0	37	wnw.	8.0
7:02 a. m....	716.7	6.4	36	wnw.	8.0	778	695.1	5.3	......	nw.	....
7:13 a. m....	716.7	6.7	36	wnw.	7.2	1272	654.0	2.3	......	nw.	....
7:23 a. m....	716.7	7.2	36	wnw.	8.0	1746	616.8	− 0.7	......	nw.	....
8:02 a. m....	716.8	8.3	33	wnw.	9.4	2850	537.2	− 1.1	......	nw.	....
8:35 a. m....	716.8	9.4	32	wnw.	10.7	3292	508.5	− 2.3	......	nw.	....
9:38 a. m....	716.7	11.0	31	wnw.	11.6	2838	539.1	− 2.6	......	nw.	....
10:20 a. m....	716.5	12.2	33	nw.	11.6	2148	588.0	− 0.3	......	nw.	....
11:19 a. m....	715.9	13.6	27	wnw.	15.2	1182	661.7	5.9	......	wnw.	....
11:38 a. m....	715.7	14.2	23	wnw.	15.2	791	693.5	9.8	......	nw.	..
11:48 a. m....	715.6	15.1	23	wnw.	14.3	526	715.6	15.1	23	wnw.	14.3

April 9.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 7500 m.; at maximum altitude, 7100 m.

There were 8/10 to 10/10 clouds consisting of Ci.-St. from the northwest and St.-Cu. from the west-northwest. The head kite was in the clouds at intervals from 8:44 to 10:06 a. m. Rain fell from 9:57 to 10:15 a. m.

Pressure was low over Maine and high over Mississippi.

April 10.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 6000 m.; at maximum altitude, 5900 m.

A few Ci.-St. from the northwest were present.

Low pressure was central over New Brunswick. Pressure was high over the upper Lakes.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. April 11.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
9:10 a.m....	715.8	12.1	36	sse.	5.4	526	715.8	12.1	36	sse.	5.4
9:29 a.m....	715.6	12.6	37	s.	6.7	888	685.5	12.0	......	sw.	....
9:46 a.m....	715.4	13.4	33	sse.	7.2	1346	648.7	9.8	......	w.	....
10:04 a.m....	715.2	13.8	34	s.	6.7	1723	619.9	8.1	......	wnw.	....
10:33 a.m....	714.9	15.1	33	s.	4.9	2532	561.5	3.1	......	w.	....
10:54 a.m....	714.6	16.0	33	s.	5.8	3251	513.2	− 2.5	......	w.	....
11:28 a.m....	714.4	16.8	35	s.	7.2	3824	477.0	− 7.3	......	w.	....
11:48 a.m....	714.3	17.8	32	sse.	7.6	4409	443.1	−10.8	......	w.	....
12:42 p.m....	713.7	19.4	29	s.	5.8	4987	410.1	−15.0	......	w.	....
1:37 p.m....	713.0	20.0	29	sse.	7.6	5959	361.7	−21.0	......	w.	....
2:21 p.m....	712.4	21.6	32	s.	8.9	7009	314.6	−27.5	......	w.	....
2:46 p.m....	712.1	21.9	26	s.	9.4	6530	335.4	−24.9	......	w.	....
3:11 p.m....	711.9	21.5	26	s.	9.8	5376	391.5	−15.7	......	w.	....
3:29 p.m....	711.7	21.7	26	sse.	8.5	4912	415.6	−13.1	......	w.	....
4:00 p.m....	711.3	21.8	26	s.	7.2	4315	448.6	− 9.0	......	w.	....
4:35 p.m....	711.2	21.2	26	sse.	8.5	2943	532.8	1.2	......	wsw.	....
4:47 p.m....	711.2	21.2	25	s.	7.6	2207	583.2	7.4	......	sw.	....
5:06 p.m....	711.2	20.8	26	sse.	7.6	949	677.1	17.2	......	s.	....
5:11 p.m....	711.1	20.8	26	sse.	6.7	526	711.1	20.8	26	sse.	6.7
April 13.											
6:43 a.m....	717.4	2.2	58	e.	8.0	526	717.4	2.2	58	e.	8.0
9:38 a.m....	718.5	5.4	46	ese.	6.3	844	690.9	2.0	......	ese.	....
9:41 a.m....	718.5	5.2	43	ese.	6.3	526	718.5	5.2	43	ese.	6.3
April 14.											
2:33 p.m....	716.7	19.6	40	se.	5.4	526	716.7	19.6	40	se.	5.4
5:45 p.m....	716.4	19.4	44	se.	5.4	750	698.0	18.7	......	s.	....
6:01 p.m....	716.4	19.0	42	se.	5.4	1356	650.1	14.7	......	sw.	....
6:11 p.m....	716.4	18.7	44	se.	5.4	1260	657.4	15.2	......	ssw.	....
6:30 p.m....	716.4	18.7	44	se.	6.7	917	684.5	15.9	......	s.	....
6:35 p.m....	716.4	18.4	42	se.	6.3	526	716.4	18.4	42	se.	6.3

April 11.—Nine kites were used; lifting surface, 58.2 sq. m. Wire out, 12900 m.; at maximum altitude, 12200 m.

Ci. and Ci.-St., from the west-northwest, increased from few at 10:30 a. m. to 7/10 at 12:30 p. m.; after 2 p. m. decreased to 1/10 at 3:30, and increased to 9/10 by 4:45 p. m. At intervals after noon there was a solar halo. A few Cu., from the west, were visible after noon.

At 8 a. m. high pressure was central over southern Virginia. Low pressure was central over Oklahoma.

April 13.—Five kites were used; lifting surface, 32.5 sq. m. Wire out, 3700 m.; at maximum altitude, 400 m.

About 2/10 Ci.-St. and 6/10 A.-St., from the west, were present at the beginning. After 8:35 a. m. there were 4/10 Ci.-St., the lower clouds having disappeared.

An extensive area of high pressure was central over the Lake region.

April 14.—Four kites were used; lifting surface, 31.1 sq. m. Wire out, 2600 m.; at maximum altitude, 1700 m.

There were a few Ci. after 6:30 p. m.

Pressure was high over Virginia and low over Kansas.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. April 15.	*mm.*	°*C.*	%		*m. p. s.*	*m.*	*mm.*	°*C.*	%		*m. p. s.*
2:20 p. m....	712.4	24.4	28	sse.	7.2	526	712.4	24.4	28	sse.	7.2
2:46 p. m....	712.2	23.7	29	s.	6.3	939	679.1	17.7	......	s.	....
3:48 p. m....	711.9	23.3	29	s.	5.8	1068	668.7	16.6	......	ssw.	....
4:16 p. m....	711.8	23.4	31	s.	4.9	1496	635.7	12.3	......	sw.	....
4:55 p. m....	711.7	23.3	33	s.	5.8	1951	602.4	9.8	......	sw.	....
5:26 p. m....	711.7	22.6	37	s.	4.9	2414	569.2	4.5	......	wsw.	....
5:36 p. m....	711.8	22.2	40	sw.	4.5	2816	541.5	0.1	......	wsw.	....
5:49 p. m....	711.8	21.8	41	wsw.	5.8	1774	614.3	6.6	......	wsw.	....
5:54 p. m....	711.8	21.6	41	w.	8.0	1313	649.0	10.7	......	wsw.	....
6:01 p. m....	711.8	21.3	44	wsw.	10.3	825	687.5	15.6	......	wsw.	....
6:05 p. m....	711.8	21.2	45	wsw.	8.9	526	711.8	21.2	45	wsw.	8.9
April 16.											
10:50 a. m....	714.6	18.5	67	se.	4.0	526	714.6	18.5	67	se.	4.0
11:56 a. m....	714.4	18.8	70	ese.	6.3	895	684.3	15.2	......	se.	....
12:27 p. m....	714.3	18.8	62	e.	9.8	1388	645.5	12.3	......	s.	....
12:40 p. m....	714.3	19.3	57	e.	9.8	1992	600.8	9.4	......	sw.	....
1:12 p. m....	714.2	20.1	53	e.	9.8	2848	542.0	5.0	......	wsw.	....
1:30 p. m....	714.2	20.4	52	e.	10.3	3137	523.3	6.0	......	wsw.	....
1:55 p. m....	714.1	20.6	49	e.	10.7	3812	481.6	1.1	......	wsw.	....
2:12 p. m....	714.1	20.0	51	e.	10.7	4070	466.2	− 2.0	......	wsw.	....
2:35 p. m....	714.0	19.8	50	e.	11.2	3806	481.6	0.0	......	sw.	....
2:54 p. m....	714.0	18.9	49	e.	11.6	3303	512.1	4.8	......	sw.	....
3:06 p. m....	714.0	18.9	49	e.	12.1	2809	543.9	6.9	......	sw.	....
3:20 p. m....	713.9	18.1	49	e.	13.4	2650	554.2	5.6	......	ssw.	....
3:34 p. m....	713.8	17.6	50	e.	13.4	2093	592.8	8.5	......	s.	....
3:56 p. m....	713.6	17.4	50	e.	14.3	1427	641.5	14.9	......	sse.	....
4:01 p. m....	713.6	17.3	50	e.	14.3	970	677.2	12.1	......	e.	....
4:22 p. m....	713.7	16.9	55	e.	13.4	526	713.7	16.9	55	e.	13.4
April 17.											
8:51 a. m....	714.8	5.0	100	se.	10.7	526	714.8	5.0	100	se.	10.7
9:02 a. m....	714.8	5.0	100	ese.	11.6	862	686.0	4.5	......	e.	....
9:06 a. m....	714.8	5.0	100	ese.	11.6	526	714.8	5.0	100	ese.	11.6

April 15.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 4000 m.; at maximum altitude, 3100 m.

Ci.-St. from the west, A.-St. from the southwest, and St.-Cu. from the west-southwest, covered the sky. There was a solar halo at 2:20 p. m., and light rain after 5:29 p. m.

At 8 a. m. high pressure was central over the Carolina coast, low pressure over Minnesota.

April 16.—Four kites were used; lifting surface, 30.1 sq. m. Wire out, 6000 m.; at maximum altitude, 5500 m.

There were about 8/10 clouds, consisting of Ci.-St. and Ci.-Cu. from the west, St.-Cu. from the south-southwest and Cu. from the southeast. The altitude of the St.-Cu. was about 3500 m. A solar halo was observed.

At 8 a. m. low pressure, central over Lake Superior, covered the Mississippi Valley and high pressure covered the St. Lawrence Valley.

April 17.—One kite was used; lifting surface, 6.3 sq. m. Wire out, 1150 m.; at maximum altitude, 1000 m.

Dense fog and light rain prevailed.

At 8 a. m. pressure was high off the New England coast and low over Wisconsin and Minnesota, with secondary low over western Virginia and North Carolina.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
April 18.	*mm.*	*°C.*	%		*m. p. s.*	*m.*	*mm.*	*°C.*	%		*m. p. s.*
8:57 a. m....	710.4	10.0	100	w.	7.6	526	710.4	10.0	100	w.	7.6
9:09 a. m....	710.4	10.0	100	w.	7.6	735	692.8	9.3	......	wsw.	....
9:20 a. m....	710.4	10.3	100	w.	7.2	674	697.9	11.3	......	ssw.	....
9:39 a. m....	710.4	11.2	98	w.	5.8	1254	650.9	8.9	......	ssw.	....
9:57 a. m....	710.4	11.9	92	w.	4.5	1782	610.3	4.4	......	sw.	....
10:18 a. m....	710.3	12.8	89	w.	2.7	1812	608.4	5.5	......	sw.	....
10:30 a. m....	710.2	13.4	85	w.	2.7	1918	600.6	5.0	......	sw.	....
10:48 a. m....	710.1	13.5	85	nw.	2.2	1422	637.6	6.5	......	sw.	....
10:58 a. m....	710.0	14.3	85	w.	1.3	526	710.0	14.3	85	w.	1.3
April 19.											
1:16 p. m....	705.7	3.2	85	nw.	11.2	526	705.7	3.2	85	nw.	11.2
1:24 p. m....	705.7	3.3	85	nw.	11.2	841	678.7	1.5	......	wnw.	....
1:38 p. m....	705.6	3.2	84	nw.	10.3	921	671.9	3.6	......	wsw.	....
1:46 p. m....	705.6	3.7	85	nw.	9.8	1325	639.2	0.4	......	sw.	....
2:14 p. m....	705.6	4.2	82	nw.	10.3	1884	596.5	− 3.4	......	sw.	....
3:17 p. m....	705.5	3.9	85	nw.	5.8	2381	558.8	− 7.3	......	sw.	....
3:47 p. m....	705.8	4.8	83	nw.	2.7	2830	528.1	− 9.4	......	ssw.	....
4:12 p. m....	705.9	4.9	82	nw.	3.6	4171	444.9	−13.1	......	s.	....
4:13 p. m....	705.9	4.9	82	nw.	3.6	526	705.9	4.9	82	nw.	3.6
April 20.											
2:05 p. m....	707.1	7.8	63	w.	8.0	526	707.1	7.8	63	w.	8.0
2:12 p. m....	707.1	7.4	67	w.	9.4	850	679.6	2.7	......	wsw.	....
2:23 p. m....	707.1	7.0	74	w.	9.4	1197	650.9	− 0.1	......	sw.	....
2:55 p. m....	707.1	5.2	89	w.	9.4	1858	598.8	− 5.0	......	sw.	....
3:11 p. m....	707.1	5.2	94	w.	8.9	2246	569.8	− 7.9	......	sw.	....
3:48 p. m....	707.2	4.6	100	w.	9.8	2710	536.7	−11.1	......	sw.	....
4:11 p. m....	707.2	4.3	100	w.	10.7	2015	586.6	− 7.5	......	sw.	....
4:40 p. m....	707.2	4.0	100	w.	9.8	1673	612.7	− 5.2	......	sw.	....
5:00 p. m....	707.2	3.9	100	w.	9.8	1075	660.5	− 1.3	......	wsw.	....
5:19 p. m....	707.3	2.8	100	w.	10.7	526	707.3	2.8	100	w.	10.7

April 18.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 2500 m., at maximum altitude.

There was dense fog until 9:11 and light fog from 9:11 to 9:30 a. m. From 6/10 to 10/10 St. from the west were visible after 9:11 a. m. at an altitude of about 1000 m.

Pressure was high over Maine and low over Ohio.

April 19.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 8000 m.; at maximum altitude, 7340 m.

The sky was covered with St.-Cu., moving from the southwest during the greater part of the flight, from the west-southwest during the latter part. The head kite entered the base of the St.-Cu. at 1:41 p. m., altitude about 1200 m.

At 8 a. m. low pressure covered the United States east of the Mississippi, with centers over northern Virginia and Lake Erie.

April 20.—Three kites were used; lifting surface, 19.4 sq. m. Wire out 5000 m.; at maximum altitude, 4200 m.

Light rain prevailed. There were 10/10 St. from the southwest during the early part of the flight and from the west during the latter part of the flight. At the beginning the base of the clouds was about 1000 m. above the surface, but during the latter part of the flight the altitude of the cloud base was less than 100 m.

Low pressure was central over Lake Erie. Pressure was high over Texas.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
April 21.	*mm.*	*C.*	%		*m. p. s.*	*m.*	*mm.*	°*C.*	%		*m. p. s.*
7:15 a. m....	708.5	4.0	76	w.	6.3	526	708.5	4.0	76	w.	6.3
7:30 a. m....	708.6	4.2	76	w.	3.6	767	687.9	2.5	......	w.	....
8:21 a. m....	708.8	4.8	74	nw.	8.0	1310	643.3	− 0.3	......	nw.	....
9:02 a. m....	708.9	5.6	70	wnw.	8.0	1703	612.4	− 3.6	......	nw.	....
10:06 a. m....	709.2	6.1	71	wnw.	8.9	1242	649.1	− 0.7	......	nw.	....
10:47 a. m....	709.3	6.2	70	wnw.	8.5	776	687.9	2.8	......	wnw.	....
10:52 a. m....	709.3	6.4	76	wnw.	8.5	526	709.3	6.4	76	wnw.	8.5
April 22.											
8:31 a. m....	713.5	6.8	74	wnw.	10.7	526	713.5	6.8	74	wnw.	10.7
8:42 a. m....	713.5	7.0	74	wnw.	10.7	824	688.2	7.0	......	nnw.	....
8:51 a. m....	713.5	7.2	79	wnw.	9.8	928	679.5	8.3	......	nnw.	....
9:22 a. m....	713.5	8.5	71	wnw.	10.7	726	696.6	11.5	......	nnw.	....
10:40 a. m....	713.5	11.0	64	wnw.	8.5	1153	661.5	6.3	......	nw.	....
10:53 a. m....	713.5	11.5	63	nw.	7.6	704	698.3	8.6	......	nw.	....
10:57 a. m....	713.5	11.8	62	nw.	7.6	526	713.5	11.8	62	nw.	7.6
April 23.											
6:55 a. m....	708.4	10.8	63	s.	7.2	526	708.4	10.8	63	s.	7.2
7:04 a. m....	708.4	10.5	64	s.	7.2	935	674.7	13.2	......	sw.	....
7:18 a. m....	708.4	10.8	63	s.	5.4	1420	636.9	12.1	......	sw.	....
7:28 a. m....	708.4	10.8	63	s.	4.5	2001	594.1	9.6	......	sw.	....
7:44 a. m....	708.4	11.3	61	s.	6.7	2306	572.6	5.1	......	sw.	....
7:57 a. m....	708.4	12.2	58	s.	7.2	2903	532.1	2.2	......	ssw.	....
8:18 a. m....	708.4	14.6	55	sw.	1.8	3445	497.5	− 2.9	......	ssw.	....
9:04 a. m....	708.5	12.9	68	s.	1.8	4177	451.7	− 9.7	......	ssw.	....
10:40 a. m....	708.7	14.1	64	se.	4.5	3271	506.9	− 3.1	......	ssw.	....
11:39 a. m....	708.6	14.6	66	sse.	4.9	2615	550.7	2.4	......	ssw.	....
12:03 p. m....	708.6	16.4	61	sse.	5.4	2001	594.1	6.2	......	ssw.	....
12:16 p. m....	708.6	16.4	59	se.	6.3	1258	649.7	10.2	......	ssw.	....
12:26 p. m....	708.6	16.6	62	se.	6.7	774	688.2	13.1	......	s.	....
12:30 p. m....	708.6	16.8	53	se.	6.7	526	708.6	16.8	53	se.	6.7

April 21.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 3500 m.; at maximum altitude, 3000 m.

About 6/10 Ci.-Cu. and A.-St. from the west were visible until 8:30 a. m., after which time they were gradually obscured by St.-Cu. from the west-northwest, the latter covering the sky after 10 a. m. Altitude about 1500 m. Light rain fell after 10:22 a. m.

At 8 a. m. lows were central over Virginia and Oklahoma and a ridge of high pressure extended from the upper Lake region to the Gulf of Mexico.

April 22.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 4200 m.; at maximum altitude, 1200 m.

There were a few St.-Cu. from the northwest after 10:34 a. m.

Pressure was high over Virginia and low off the New England coast.

April 23.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 7500 m.; at maximum altitude.

Ci.-St. from the southwest, and St.-Cu. from the south-southwest, almost covered the sky until 9:30 a. m. Ci.-St. and A.-St., from the southwest, covered the sky until 11:30 a. m., then slowly decreased to 5/10. There was a solar halo at intervals from 7:57 to 10:15 a. m.

Low pressure, central over Michigan, covered the United States east of the Mississippi.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m. Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	At different heights above sea. Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. April 25.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
10:19 a. m....	712.3	12.0	76	se.	7.6	526	712.3	12.0	76	se.	7.6
10:30 a. m....	712.3	11.9	74	se.	8.9	916	679.7	7.6	......	sse.	....
10:59 a. m....	712.2	12.9	59	se.	8.9	1504	632.8	3.7	......	s.	....
11:16 a. m....	712.3	13.5	50	se.	11.6	2079	589.9	0.5	......	s.	....
11:20 a. m....	712.3	13.3	50	se.	8.9	2360	569.8	2.0	......	s.	....
11:28 a. m....	712.3	12.8	44	se.	10.7	2706	545.7	0.7	......	s.	....
11:41 a. m....	712.3	12.8	42	se.	10.7	3622	486.1	− 6.6	......	s.	....
11:58 a. m....	712.4	12.5	48	se.	12.5	4059	459.7	− 8.6	......	s.	....
2:45 p. m....	711.7	14.0	48	se.	8.0	526	711.7	14.0	48	se.	8.0
April 26.											
7.09 a. m....	712.1	2.1	88	s.	8.9	526	712.1	2.1	88	s.	8.9
7:14 a. m....	712.2	2.2	90	s.	8.5	882	681.5	1.0	......	ssw.	....
7:23 a. m....	712.2	2.4	90	s.	8.9	1314	646.0	2.0	......	ssw.	....
7:54 a. m....	712.5	2.3	86	s.	7.2	1935	597.7	− 2.0	......	sw.	....
8:03 a. m....	712.5	2.8	86	s.	6.7	2043	589.8	− 0.6	......	sw.	....
8:22 a. m....	712.6	3.2	84	s.	6.7	2888	530.2	− 5.9	......	sw.	....
8:46 a. m....	712.7	3.9	78	s.	6.7	3577	485.6	−10.5	......	sw.	....
9:32 a. m....	712.9	6.8	75	s.	4.9	4139	451.6	−15.1	......	sw.	....
10:15 a. m....	713.0	7.7	68	se.	6.7	4522	429.4	−17.6	......	sw.	....
10:50 a. m....	713.0	7.9	63	wsw.	2.7	4393	436.8	−16.7	......	sw.	....
11:16 a. m....	713.0	8.5	53	wsw.	3.6	3066	519.9	− 7.0	......	sw.	....
11:31 a. m....	713.0	8.4	61	w.	3.1	1987	595.9	0.0	......	wsw.	....
11:35 a. m....	713.0	8.7	59	wsw.	3.6	526	713.0	8.7	59	wsw.	3.6
April 27.											
1st flight:											
9:19 a. m....	713.7	8.8	77	se.	5.8	526	713.7	8.8	77	se.	5.8
10:02 a. m....	713.8	10.0	72	se.	6.3	996	674.3	4.9	......	s.	....
11:30 a. m....	713.6	11.6	59	se.	4.0	526	713.6	11.6	59	se.	4.0
2d flight:											
12:53 p. m....	713.3	12.4	52	s.	7.6	526	713.3	12.4	52	s.	7.6
1:17 p. m....	713.4	11.8	54	s.	5.4	774	692.5	8.7	......	s.	....
2:43 p. m....	713.8	10.4	68	sse.	4.9	895	682.7	6.0	......	s.	....
3:12 p. m....	713.9	10.2	69	ssw.	2.7	1216	656.4	3.4	......	ssw.	....
3:18 p. m....	714.0	10.0	70	ssw.	2.7	942	678.9	5.3	......	ssw.	....
3:22 p. m....	714.0	10.0	70	ssw.	3.1	741	695.7	7.0	......	ssw.	....
3:27 p. m....	714.0	10.0	70	ssw.	3.1	526	714.0	10.0	70	ssw.	3.1

April 25.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 8000 m.; at maximum altitude, 7300 m.

The sky was from 8/10 to 10/10 covered with A.-St. and St.-Cu., from the south. The base of the higher clouds was about 3800 m. and the base of the lower clouds about 1000 m. above sea level.

Centers of low pressure were over Lake Erie and western North Carolina. A ridge of high pressure extended from Minnesota to Texas.

April 26.—Seven kites were used; lifting surface, 44.1 sq. m. Wire out, 8750 m.; at maximum altitude, 8500 m.

1/10 to 6/10 St.-Cu. from the south-southwest at an altitude of 800 m. changed to west-southwest by 9:27 a. m.

Pressure was high over New Brunswick and low over Michigan.

April 27.—First flight: Two kites were used; lifting surface, 13.1 sq. m. Wire out, 1200 m., at maximum altitude.

There were 2/10 Cu. from the south-southwest.

Second flight: Three kites were used; lifting surface, 19.4 sq. m. Wire out, 2200 m.; at maximum altitude, 1300 m.

The sky was almost covered with St.-Cu. from the south-southwest.

At 8 a. m. centers of low pressure lay over the lower St. Lawrence and over Kentucky. High pressure was central north of Lake Superior.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. April 28.	*mm.*	*° C.*	%		*m. p. s.*	*m.*	*mm.*	*° C.*	%		*m. p. s.*
6:51 a. m.	716.2	5.5	80	nw.	9.4	526	716.2	5.5	80	nw.	9.4
7:02 a. m.	716.2	5.8	79	nw.	8.9	856	688.0	4.1	......	nnw.	......
7:15 p. m.	716.2	6.1	77	nw.	10.7	1369	645.6	0.8	......	nnw.	......
7:29 a. m.	716.2	6.5	76	nw.	10.7	1898	604.5	1.7	......	nnw.	......
7:48 a. m.	716.3	6.9	74	nw.	11.6	2570	556.2	− 0.9	......	nnw.	......
8:05 a. m.	716.3	7.2	72	nw.	11.2	2971	529.0	− 2.3	......	nnw.	......
8:31 a. m.	716.5	7.6	73	nw.	9.8	3504	494.7	− 5.4	......	nnw.	......
10:38 a. m.	716.8	10.1	55	nw.	12.1	4190	453.4	−10.9	......	nnw.	......
11:24 a. m.	716.8	10.1	55	nw.	10.3	3418	500.3	− 5.8	......	nnw.	......
11:34 a. m.	716.7	10.4	53	nw.	8.5	2785	542.1	− 1.9	......	nnw.	......
12:00 m.	716.7	10.8	54	nw.	8.5	2045	594.7	0.6	......	nnw.	......
12:09 p. m.	716.7	11.0	49	nw.	8.0	1786	614.3	− 1.4	......	nnw.	......
12:19 p. m.	716.7	11.1	50	nw.	8.5	1222	658.7	3.6	......	nnw.	......
12:24 p. m.	716.7	11.3	51	nw.	8.5	825	691.4	7.2	......	nnw.	......
12:31 p. m.	716.7	11.6	51	nw.	10.7	526	716.7	11.6	51	nw.	10.7
April 29.											
8:13 a. m.	716.9	8.4	54	s.	7.2	526	716.9	8.4	54	s.	7.2
8:18 a. m.	716.8	8.6	56	s.	8.0	842	690.0	9.5	......	ssw.	......
9:55 a. m.	715.9	11.1	51	se.	7.6	1210	659.5	9.9	......	sw.	......
10:27 a. m.	715.5	12.0	52	se.	8.0	3305	510.1	0.5	......	wnw.	......
10:45 a. m.	715.2	12.5	44	se.	8.5	3779	480.3	− 2.9	......	wnw.	......
11:30 a. m.	714.6	14.0	48	se.	9.4	4412	442.7	− 8.1	......	wnw.	......
12:08 p. m.	714.1	13.9	51	se.	8.9	4020	464.9	− 6.0	......	wnw.	......
12:30 p. m.	714.0	14.0	51	se.	10.7	3526	495.2	− 2.4	......	wnw.	......
1:00 p. m.	713.8	13.6	54	sse.	9.8	2828	540.7	3.6	......	wnw.	......
1:23 p. m.	713.7	13.8	56	sse.	9.4	2184	585.2	7.5	......	wnw.	......
1:40 p. m.	713.7	13.7	57	sse.	8.0	1531	634.4	9.5	......	wsw.	......
1:53 p. m.	713.6	13.8	57	sse.	7.2	874	684.7	10.5	......	s.	......
1:57 p. m.	713.6	13.8	57	sse.	5.8	526	713.6	13.8	57	sse.	5.8
April 30.											
8:32 a. m.	710.2	21.4	36	w.	13.0	526	710.2	21.4	36	w.	13.0
8:39 a. m.	710.2	21.4	36	w.	13.4	882	681.6	19.0	......	w.	......
8:56 a. m.	710.2	22.0	37	w.	10.3	1795	612.9	15.1	......	w.	......
9:08 a. m.	710.2	22.4	35	w.	13.0	2200	584.4	13.2	......	w.	......
9:41 a. m.	710.4	23.2	35	w.	12.1	2981	532.2	9.1	......	w.	......
10:02 a. m.	710.4	23.7	37	w.	8.5	3770	483.8	3.2	......	w.	......
11:00 a. m.	710.5	25.9	34	w.	12.1	4458	444.3	− 3.4	......	w.	......
11:12 a. m.	710.5	26.2	31	w.	11.2	3968	472.6	0.7	......	w.	......
11:39 a. m.	710.4	26.2	34	w.	10.7	3257	516.3	7.4	......	w.	......
12:00 m.	710.3	26.9	28	w.	12.1	1996	599.6	14.7	......	w.	......
12:16 p. m.	710.3	27.0	31	w.	9.8	1637	625.1	15.4	......	w.	......
12:28 p. m.	710.3	27.4	29	w.	12.5	1251	653.7	18.5	......	w.	......
12:37 p. m.	710.3	27.6	30	w.	12.5	846	685.0	22.8	......	w.	......
12:40 p. m.	710.2	27.6	32	w.	11.6	526	710.2	27.6	32	w.	11.6

April 28.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 9100 m.; at maximum altitude, 7000 m.

At the beginning there were 2/10 Ci.-St. from the west. St.-Cu. from the north-northwest appeared at 8 a. m. and increased to 8/10 by 9 a. m.; altitude between 1800 and 2000 m.

At 8 a. m. high pressure, central north of the Lakes, covered the eastern United States.

April 29.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 8000 m.; at maximum altitude, 7200 m.

There were a few to 10/10 A.-Cu. and A.-St. from the west, changing to west-northwest before 10:30 a. m. 2/10 to a few Ci.-St. from the west-northwest were observed from 10:44 to 11:45 a. m. There was a solar halo.

Pressure was high along the Atlantic coast and low over Minnesota.

April 30.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 10000 m.; at maximum altitude, 7900 m.

Ci., A.-St., and A.-Cu., from the northwest, covered from 7/10 to 10/10 of the sky.

Low pressure was central over the upper St. Lawrence, and high pressure over Florida.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity					Dir.	Velocity.
1910.											
May 1.	mm.	°C.	%		m. p. s.	m.	mm.	°C.	%		m. p. s.
8:28 a. m....	717.5	16.2	76	ese.	7.2	526	717.5	16.2	76	ese.	7.2
8:54 a. m....	717.5	16.9	74	se.	7.2	994	679.5	18.6	......	sw.	....
9:09 a. m....	717.5	17.4	73	se.	7.2	1586	634.0	14.1	......	wsw.	....
9:21 a. m....	717.6	17.6	73	se.	8.0	1978	605.0	10.2	......	wsw.	....
10:33 a. m....	717.6	19.1	68	se.	8.0	2201	589.0	7.5	......	wsw.	....
11:12 a. m....	717.6	19.6	66	se.	8.0	1477	642.1	14.6	......	sw.	....
11:29 a. m....	717.5	20.0	64	se.	8.0	1062	674.4	18.3	......	sw.	....
12:14 p. m....	717.3	21.8	60	se.	8.0	860	690.2	18.7	......	sw.	....
12:35 p. m....	717.1	22.4	58	se.	8.5	526	717.1	22.4	58	se.	8.5
May 2.											
1:39 p. m....	718.2	15.4	85	se.	6.3	526	718.2	15.4	85	se.	6.3
2:12 p. m....	718.0	15.9	85	se.	6.7	653	707.6	24.0	......	sse.	....
2:40 p. m....	717.8	17.0	83	se.	8.0	1542	638.6	17.8	......	ssw.	....
3:04 p. m....	717.6	17.6	79	se.	8.0	2499	570.1	9.8	......	ssw.	....
3:12 p. m....	717.5	17.8	81	se.	8.5	2982	537.5	5.8	......	sw.	....
3:46 p. m....	717.3	19.0	74	se.	8.5	3486	505.0	1.6	......	sw.	....
3:58 p. m....	717.2	19.2	72	se.	10.3	3093	530.0	4.5	......	sw.	....
4:29 p. m....	717.1	19.0	72	se.	11.2	2529	567.4	9.4	......	sw.	....
4:59 p. m....	717.0	19.0	74	se.	10.7	1688	626.8	16.2	......	ssw.	....
5:10 p. m....	716.9	18.8	76	se.	10.3	1218	661.9	20.1	......	s.	....
5:20 p. m....	716.8	18.2	78	se.	9.8	848	690.7	21.5	......	sse.	....
5:24 p. m....	716.8	18.2	78	se.	10.7	526	716.8	18.2	78	se.	10.7
May 3.											
4:06 p. m....	715.1	17.5	83	nw.	8.9	526	715.1	17.5	83	nw.	8.9
4:10 p. m....	715.1	17.8	80	nw.	8.5	805	692.3	19.5	......	nw.	....
4:23 p. m....	715.0	18.8	72	nw.	9.4	1318	652.1	16.9	......	w.	....
4:37 p. m....	714.9	19.7	66	nw.	10.7	1839	613.4	13.0	......	wsw.	....
4:54 p. m...	714.8	19.4	65	nw.	9.4	2441	570.6	7.8	......	wsw.	....
5:16 p. m....	715.0	19.3	65	nw.	10.3	2688	553.1	6.0	......	wsw.	....
5:36 p. m...	715.3	20.4	55	nw.	10.7	1780	617.5	11.6	......	wsw.	....
5:54 p. m....	715.5	20.0	60	nw.	11.2	853	688.9	17.7	......	nw.	....
6:02 p. m....	715.6	19.8	62	nw.	9.4	526	715.6	19.8	62	nw.	9.4

May 1.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 3680 m.; at maximum altitude, 3200 m.

There were 7/10 Ci.-St. from the west.

Pressure was high over the St. Lawrence Valley. Pressure was low over the middle Mississippi Valley and relatively low off the North Carolina coast.

May 2.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 5000 m.; at maximum altitude, 4300 m.

There were a few A.-Cu. near the horizon after 3:50 p. m.

Pressure was high over the New England coast and was low over Missouri.

May 3.—Two kites were used; lifting surface, 12.6 sq. m. Wire out, 4200 m.; at maximum altitude, 3600 m.

The flight occurred just after a heavy thundershower. The sky was covered with St.-Cu. from the west-southwest until 5:10 p. m., and with St.-Cu. from the west-southwest and A.-St. from the southwest thereafter.

Pressure was high over Minnesota and relatively low over Pennsylvania.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910.											
May 4.	*mm.*	*° C.*	*%*		*m. p. s.*	*m.*	*mm.*	*° C.*	*%*		*m. p. s.*
10:45 a. m....	719.6	9.9	69	nw.	14.8	526	719.6	9.9	69	nw.	14.8
10:47 a. m....	719.6	9.7	64	nw.	14.3	858	691.2	5.1	......	nw.	....
11:57 a. m....	719.5	10.7	61	nw.	12.5	1555	635.0	3.2	......	nnw.	....
1:23 p. m....	719.3	12.4	56	nw.	10.7	1208	662.4	3.7	......	nw.	....
1:38 p. m....	719.3	12.6	55	nw,	10.3	878	689.5	6.3	......	nw.	....
1:45 p. m....	719.3	12.1	53	nnw.	11.2	526	719.3	12.1	53	nnw.	11.2
May 5.											
6:43 a. m....	721.3	2.8	66	nw.	7.2	526	721.3	2.8	66	nw.	7.2
6:50 a. m....	721.3	2.8	66	nw.	6.7	907	688.1	1.6	......	nnw.	....
7:06 a. m....	721.4	2.9	66	nw.	5.4	1392	647.5	− 2.7	......	nnw.	....
7:24 a. m...	721.4	3.6	67	nw.	6.3	1866	610.1	− 1.8	......	nnw.	....
7:41 a. m....	721.4	4.1	68	nw.	5.4	2651	552.5	− 5.0	......	nnw.	....
8:06 a. m....	721.4	4.9	67	nw.	6.3	3428	500.4	−10.3	......	nnw.	....
8:32 a. m....	721.4	5.7	57	nw.	8.9	4461	437.4	−15.9	......	nw.	....
9:35 a. m....	721.4	7.2	43	nw.	9.8	5132	400.1	−20.7	......	nw.	....
11:38 a. m....	721.0	9.2	42	nw.	6.7	6222	345.7	−27.4	......	nw.	....
1:23 p. m....	720.4	10.8	32	nw.	6.7	7265	299.9	−32.5	......	nw.	....
2:16 p. m....	720.1	12.4	31	nw.	6.3	6625	328.6	−28.8	......	nw.	....
4:44 p. m....	719.4	12.7	23	nw.	8.0	4152	457.2	−14.0	......	nw.	....
5:11 p. m....	719.3	12.4	24	nw.	8.0	2740	546.9	− 8.4	......	nw.	....
5:28 p. m....	719.3	12.4	26	nw.	6.3	1899	608.3	− 1.1	......	nw.	....
5:39 p. m....	719.3	12.4	26	nw,	6.3	1371	649.3	3.6	......	nw.	....
5:45 p. m....	719.3	12.4	26	nw.	5.4	919	686.2	7.7	......	nw.	....
5:52 p. m....	719.3	12.4	27	nw.	6.3	526	719.3	12.4	27	nw.	6.3
May 6.											
6:56 a. m....	721.0	3.3	53	nw.	6.3	526	721.0	3.3	53	nw.	6.3
7:09 a. m....	721.0	3.8	52	wnw.	6.3	889	689.4	2.0	......	nnw.	....
7:23 a. m....	721.0	4.0	51	nw.	7.2	1299	655.0	− 1.1	......	nw.	....
8:06 a. m....	721.0	4.8	56	nw.	6.7	1840	612.3	− 0.9	......	nw.	....
9:10 a. m....	721.0	7.3	51	nw.	6.3	2158	589.0	− 3.7	......	nw.	....
9:33 a. m....	720.8	7.8	46	n.	6.7	3285	510.2	−10.0	......	nw.	....
9:55 a. m....	720.5	7.9	40	n.	6.7	3145	519.5	− 8.6	......	nw.	....
10:17 a. m....	720.5	8.8	37	n.	7.6	2494	564.4	− 5.8	......	nw.	....
10:43 a. m....	720.3	8.7	35	nw.	7.2	1186	664.4	0.9	......	nw.	....
11:01 a. m....	720 3	9.2	32	nw.	6.7	767	699.5	4.9	......	nw.	....
11:09 a. m....	720.3	9.2	32	nw.	8.0	526	720.3	9.2	32	nw.	8.0

May 4.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 6000 m.; at at maximum altitude, 4700 m.

Cu. from the northwest covered from 3/10 to 1/10 of the sky.

High pressure, central over Lake Superior, covered the United States east of the Rocky Mountains. Pressure was relatively low off the middle Atlantic coast.

May 5.—Ten kites were used; lifting surface, 63.5 sq. m. Wire out, 14000 m.; at maximum altitude, 13750 m.

At the beginning the sky was cloudless. After 8:29 a. m. there were a few Cu. from the northwest.

An extensive area of high pressure, central over the upper Lakes, covered the eastern half of the country.

May 6.—Six kites were used; lifting surface, 38,3 sq. m. Wire out, 5000 m.; at maximum altitude, 4000 m.

There were from a few to 2/10 Ci.-St. from the northwest after 7:58 a. m.

High pressure central over the upper Lakes covered the eastern half of the country.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
May 7.	*mm.*	*° C.*	%		*m. p. s.*	*m.*	*mm.*	*° C.*	%		*m. p. s.*
1:00 p. m....	716.8	16.5	31	s.	7.2	526	716.8	16.5	31	s.	7.2
1:14 p. m....	716.7	15.8	31	ssw.	5.8	892	686.4	12.1	......	s.	....
1:34 p. m....	716.6	16.1	32	s.	6.3	1364	648.6	7.9	......	s.	....
2:12 p. m....	716.4	16.1	37	s.	6.3	1795	615.4	5.0	......	s.	....
2:31 p. m....	716.3	16.3	37	s.	6.7	2308	578.0	2.0	......	ssw.	....
3:33 p. m....	716.2	15.8	39	ssw.	8.0	2714	549.5	− 0.5	......	ssw.	....
3:46 p. m....	716.2	15.1	43	ssw.	7.2	1888	607.6	2.0	......	ssw.	....
3:57 p. m....	716.2	14.8	45	s.	7.2	1404	644.6	5.8	......	s.	....
4:05 p. m....	716.2	14.7	47	s.	7.6	905	684.7	10.3	......	s.	....
4:09 p. m....	716.2	14.6	47	s.	8.5	526	716.2	14.6	47	s.	8.5
May 8.											
11:38 a. m....	713.1	15.2	90	sse.	5.4	526	713.1	15.2	90	sse.	5.4
11:45 a. m....	713.0	15.4	88	s.	5.8	789	691.3	14.8	......	s.	....
12:37 p. m....	712.6	16.8	84	sse.	7.2	1086	667.1	14.0	......	s.	....
1:21 p. m....	712.4	17.4	81	sse.	6.7	1497	635.4	12.6	......	wsw.	....
1:27 p. m....	712.4	18.3	78	sse.	6.3	1295	650.7	14.3	......	wsw.	....
1:35 p. m....	712.5	18.2	77	sse.	6.3	764	693.0	15.0	......	w.	....
1:40 p. m....	712.5	18.4	80	sse.	6.3	526	712.5	18.4	80	sse.	6.3
May 9.											
6:58 a. m....	710.2	14.2	93	nw.	8.0	526	710.2	14.2	93	nw.	8.0
7:07 a. m....	710.2	14.2	96	nw.	8.9	853	683.1	11.8	......	wnw.	....
7:23 a. m....	710.2	14.0	93	nw.	8.9	1159	658.5	9.5	......	wnw.	....
7:34 a. m....	710.2	14.0	93	nw.	8.0	1161	658.5	11.8	......	wnw.	....
7:43 a. m....	710.2	14.6	90	wnw.	8.9	1312	647.0	11.9	......	wnw.	....
8:43 a. m....	710.3	14.6	90	wnw.	9.4	2007	594.7	5.8	......	wsw.	....
9.03 a. m....	710.4	15.2	84	wnw.	10.7	3312	506.1	− 2.3	......	sw.	....
9:15 a. m....	710.4	15.2	72	wnw.	10.7	3779	477.4	− 4.4	......	sw.	....
9:34 a. m....	710.4	15.5	65	wnw.	10.7	4458	438.0	− 8.4	......	sw.	....
10:50 a. m....	710.2	15.9	57	w.	13.4	3752	479.3	− 3.8	......	sw.	....
11:10 a. m....	710.2	16.0	54	wnw.	13.4	3229	511.7	− 1.5	......	sw.	....
11:28 a. m....	710.1	15.9	54	wnw.	16.1	2507	559.3	2.8	......	sw.	....
11:40 a. m....	710.0	15.3	54	wnw.	16.1	2079	589.2	4.2	......	sw.	....
11:53 a. m....	709.9	15.4	53	wnw.	16.1	1155	658.5	7.7	......	wnw	....
12:08 p. m....	709.9	15.2	51	wnw.	17.9	830	684.8	10.7	......	wnw.	....
12:13 p. m....	709.9	15.3	51	w.	17.9	526	709.9	15.3	51	w.	17.9

May 7.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 3200 m.; at maximum altitude, 2600 m.

7/10 to 8/10 Ci.-Cu. and Ci.-St. from the west were concealed by St.-Cu. from the south-southwest after 3:30 p. m. The head kite was in the clouds from 3:30 to 3:38 p. m. There was a solar halo.

Pressure was high off the Carolina coast and low over New Brunswick and Missouri.

May 8.—Three kites were used; lifting surface, 19.4 sq. m. Wire out, 2000 m.; at maximum altutude, 1300 m.

The sky was nearly covered with A.-St. from the southwest and St.-Cu from the south-southeast until 12:30 m. p. Thereafter about 7/10 A.-St. from the west-southwest and Cu. from the south. The head kite entered St. Cu. at 11:47 a. m.

An area of low pressure, central over Illinois, covered the eastern portion of the United States. The pressure was relatively high off the Atlantic coast.

May 9.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 8000 m.; at maximum altitude, 7100 m.

At the beginning the sky was 9/10 covered with Ci.-Cu. and St.-Cu. from the west-southwest. The clouds diminished to 2/10 by the end of the flight.

Low pressure was central over Ontario. Centers of high pressure were over Mississippi and North Dakota.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
May 10.	*mm.*	°*C.*	%		*m. p. s.*	*m.*	*mm.*	°*C.*	%		*m. p. s.*
4:52 p. m....	712.1	19.2	44	s.	2.7	526	712.1	19.2	44	s.	2.7
5:08 p. m....	712.0	19.4	41	ssw.	2.7	1407	641.9	12.0	......	w.	....
5:25 p. m....	711.7	19.3	42	s.	3.6	859	684.7	16.9	......	sw.	....
5:52 p. m....	711.6	19.4	44	ssw.	5.4	526	711.6	19.4	44	ssw.	5.4
May 11.											
7:09 a. m....	711.1	14.1	60	nnw.	8.5	526	711.1	14.1	60	nnw.	8.5
7:17 a. m....	711.3	13.8	62	nnw.	8.5	816	687.3	12.4	......	nw.	....
7:27 a. m....	711.5	13.6	62	nnw.	9.4	1228	653.9	6.1	......	wnw.	....
7:40 a. m....	711.8	12.7	71	nnw.	9.4	1450	636.7	4.9	......	wnw.	....
7:48 a. m....	711.8	12.6	70	nnw.	9.4	1909	601.8	3.9	......	wnw.	....
7:59 a. m....	712.0	12.5	69	nnw.	8.5	2232	578.5	4.2	......	w.	....
8:12 a. m....	712.0	12.0	73	nnw.	7.2	2947	529.6	0.8	......	wsw.	....
8:30 a. m....	712.0	11.7	77	nnw.	8.0	3324	505.3	− 0.7	......	wsw.	....
8:40 a. m....	712.0	11.7	77	nnw.	8.0	526	712.0	11.7	77	nnw.	8.0
May 12.											
4:12 p. m....	712.3	13.0	47	wnw.	8.5	526	712.3	13.0	47	wnw.	8.5
4:19 p. m....	712.3	13.6	39	wnw.	7.2	1174	659.0	7.0	......	nw.	....
4:46 p. m....	712.2	13.3	45	nnw.	7.2	901	681.0	9.1	......	nnw.	....
4:52 p. m....	712.2	13.4	43	nnw.	7.2	526	712.2	13.4	43	nnw.	7.2
May 13.											
6:51 a. m....	715.6	4.2	65	nw.	6.7	526	715.6	4.2	65	nw.	6.7
7:05 a. m....	715.6	4.3	65	nw.	5.4	765	694.8	3.0	......	nw.	....
7:22 a. m....	715.6	4.7	66	wnw.	6.7	1246	654.6	0.2	......	nnw.	....
8:00 a. m....	715.6	5.7	62	nw.	6.7	1612	625.7	− 0.9	......	nnw.	....
8:34 a. m....	715.5	6.4	56	nw.	6.7	2150	584.6	− 5.2	......	n.	....
9:49 a. m....	715.5	8.0	47	nnw.	7.2	2426	564.6	− 7.6	......	nnw.	....
9:57 a. m....	715.5	8.1	44	nnw.	7.2	2588	552.6	− 6.1	......	nnw.	....
10:26 a. m....	715.5	8.4	50	nnw.	6.3	2334	571.0	− 6.7	......	nw.	....
10:30 a. m....	715.4	8.4	51	nnw.	5.4	1969	598.1	− 5.7	......	nw.	....
10:46 a. m....	715.4	9.0	46	nw.	5.4	990	676.0	2.0	......	nw.	....
10:58 a. m....	715.4	9.0	44	nnw.	5.4	688	701.6	6.2	......	nnw.	....
11:01 a. m....	715.4	8.8	44	nw.	5.8	526	715.4	8.8	44	nw.	5.8

May 10.—One balloon was used. Capacity, 31.1 cu. m. Wire out, 2020 m.
The sky was covered with St.-Cu.
An area of high pressure was central over Alabama. Low pressure was central over New Brunswick

May 11.—Two kites were used; lifting surface, 12.6 sq. m. Wire out, 4500 m.; at maximum altitude, 4350 m.
The sky was covered with St.-Cu. from the west-southwest until 8:00 a. m. and with A.-St. and St.-Cu. from the west-southwest thereafter. Light rain fell from 7:24 to 8:11 a. m. The head kite was in the clouds after 8:18 a. m., except at short intervals.
Pressure was high over Florida and low over the Gulf of St. Lawrence.

May 12.—One balloon was used; capacity, 31.1 cu. m. Wire out, 1800 m.
There were 9/10 St. from the northwest.
Areas of low pressure were central over North Carolina and the lower St. Lawrence. A high was central over North Dakota.

May 13.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 5800 m.; at maximum altitude, 4600 m.
A few Ci.-St. from the southwest increased to 6/10 by the end of the flight. A few Cu. from the north-northwest were present after 7:49 a. m.
High pressure was central over South Dakota. There was a slight depression off the middle Atlantic coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
May 14.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
6:49 a. m....	717.1	3.6	82	wnw.	7.2	526	717.1	3.6	82	wnw.	7.2
8:56 a. m....	717.5	3.2	81	wnw.	10.7	805	693.3	3.4	......	nw.	....
9:07 a. m....	717.5	3.2	81	wnw.	10.7	1044	672.8	− 0.6	......	nw.	....
9:16 a. m....	717.6	3.0	84	nw.	9.8	824	691.6	− 0.1	......	nw.	....
9:23 a. m....	717.7	2.8	87	nw.	8.9	526	717.7	2.8	87	nw.	8.9
May 15.											
7:00 a. m....	722.0	3.6	88	nw.	6.3	526	722.0	3.6	88	nw.	6.3
7:10 a. m....	722.0	3.6	88	nw.	7.2	867	692.2	2.7	......	nnw.	....
7:42 a. m....	722.1	5.1	80	nw.	8.0	1241	661.2	1.8	......	nnw.	....
8:04 a. m....	722.2	5.6	80	nw.	7.2	1605	631.9	− 1.1	......	nnw.	....
8:27 a. m....	722.3	6.0	76	nw.	7.6	1900	608.9	− 4.0	......	nw.	....
9:15 a. m....	722.4	7.1	71	nw.	6.7	2104	593.5	− 6.1	......	nnw.	....
9:28 a. m....	722.5	7.7	64	nw.	7.2	1531	638.3	− 1.3	......	nw.	....
9:36 a. m....	722.5	7.8	57	nnw.	7.2	1087	674.4	1.0	......	nnw.	....
9:46 a. m....	722.6	7.7	54	nnw.	6.3	779	700.6	4.3	......	nnw.	....
9:50 a. m....	722.6	8.0	54	nnw.	5.8	526	722.6	8.0	54	nnw.	5.8
May 16.											
3:06 p. m....	724.6	15.0	44	ese.	4.5	526	724.6	15.0	44	ese.	4.5
3:31 p. m....	724.6	15.6	43	se.	5.4	2887	545.1	2.1	......	calm.	....
3:40 p. m....	724.6	16.0	44	se.	4.0	2309	585.1	4.6	......	calm.	....
3:50 p. m....	724.6	15.5	43	s.	4.5	1643	634.0	6.8	......	calm.	....
4:00 p. m....	724.6	14.8	38	s.	3.6	884	694.2	11.6	......	se.	....
4:09 p. m....	724.6	15.2	46	se.	6.3	526	724.6	15.2	46	se.	6.3
May 17.											
6:55 a. m....	725.0	10.4	59	s.	6.3	526	725.0	10.4	59	s.	6.3
7:04 a. m....	725.0	10.4	59	s.	6.3	910	692.3	8.8	......	s.	....
7:22 a. m....	725.0	10.9	60	s.	5.8	1313	659.2	5.9	......	s.	....
7:45 a. m....	725.0	11.1	60	s.	5.8	1940	610.6	4.3	......	s.	....
8:40 a. m....	724.9	12.8	54	s.	8.9	2299	584.5	5.7	......	s.	....
10:14 a. m....	724.2	14.6	47	s.	8.9	2719	554.7	3.0	......	ssw.	....
10:37 a. m....	723.8	15.4	43	s.	8.9	3400	510.1	0.4	......	s.	....
10:46 a. m....	723.7	15.1	42	s.	10.7	2846	546.3	2.3	......	s.	....
11:20 a. m....	723.3	15.9	40	sse.	11.6	2230	589.0	5.0	......	ssw.	....
11:30 a. m....	723.2	15.5	40	s....	10.7	1603	635.5	7.9	......	ssw.	....
11:46 a. m....	723.1	15.8	40	s.	10.3	1300	659.2	6.7	......	sse.	....
11:56 a. m....	723.0	16.3	41	sse.	10.3	828	697.6	10.7	......	sse.	....
12:06 p. m....	722.9	16.4	38	sse.	10.3	526	722.9	16.4	38	sse.	10.3

May 14.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 3875 m.; at maximum altitude, 900 m.

St.-Cu., from the west-southwest, increased from 5/10 to 10/10 by 8:15 a. m. Light rain fell from 8:35 to 9:16 a. m., and wet snow, sleet, and rain thereafter.

High pressure, central over the Lake region, covered the eastern United States.

May 15.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 4300 m.; at maximum altitude, 3000 m.

From 5/10 to a few A.-Cu. from the west before 7:42 a. m., and from a few to 7/10 St.-Cu. from the northwest after 7:40 a. m.

Pressure was high over Ontario and low over North Dakota.

May 16.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2500 m.

3/10 to 1/10 Ci. from the northwest and 7/10 A.-St. from the north to north-northwest were observed during the flight. A solar halo was visible from 2:29 p. m. until 3:50 p. m.

Low pressure was central over the Dakotas. High pressure, central over New Jersey, covered the eastern portion of the United States.

May 17.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 7100 m.; at maximum altitude, 5500 m.

The sky was cloudless.

Low pressure was central over Wisconsin. Pressure was high over the middle Atlantic coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m. Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	At different heights above sea. Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910.											
May 18.	*mm.*	*° C.*	%		*m. p. s.*	*m.*	*mm.*	*° C.*	%		*m. p. s.*
6:57 a. m....	714.3	13.2	78	w.	10.3	526	714.3	13.2	78	w.	10.3
7:06 a. m....	714.3	13.1	81	w.	10.3	891	683.9	10.1	......	w.	....
7:16 a. m....	714.3	12.4	88	wnw.	8.9	1239	655.5	6.6	......	wnw.	....
7:32 a. m....	714.2	12.2	90	wnw.	11.2	1789	612.9	3.2	......	w.	....
7:54 a. m....	714.2	13.2	79	w.	10.7	2139	587.3	2.7	......	w.	....
8:06 a. m....	714.2	13.4	80	w.	11.2	3036	525.4	− 0.5	......	w.	....
8:35 a. m....	714.1	14.2	75	wnw.	10.7	3384	503.0	− 1.3	......	wnw.	....
9:15 a. m....	714.1	14.9	57	wnw.	13.4	4243	451.6	− 4.4	......	wnw.	....
1:23 p. m....	714.0	18.0	42	wnw.	14.3	526	714.0	18.0	42	wnw.	14.3
May 19.											
6:44 a. m....	717.5	14.2	55	wnw.	8.9	526	717.5	14.2	55	wnw.	8.9
6:49 a. m....	717.5	14.3	55	wnw.	8.9	882	688.0	12.0	......	wnw.	....
7:00 a. m....	717.5	14.5	55	wnw.	8.9	1294	654.6	8.6	......	wnw.	....
7:10 a. m....	717.5	14.4	56	wnw.	9.4	1442	643.0	7.0	......	nw.	....
7:19 a. m....	717.5	14.4	56	wnw.	9.8	1851	612.0	8.6	......	nw.	....
7:29 a. m....	717.5	14.7	56	wnw.	9.8	2256	582.8	7.4	......	nw.	....
7:51 a. m....	717.6	15.6	56	wnw.	8.9	2751	548.8	4.1	......	nw.	....
8:38 a. m....	717.6	16.2	53	wnw.	7.6	3321	511.4	− 0.8	......	nw.	....
9:37 a. m....	718.1	17.2	53	wnw.	8.0	3971	471.6	− 6.0	......	wnw.	....
9:50 a. m....	718.2	17.6	53	wnw.	7.6	3390	507.7	− 2.5	......	nw.	....
10:06 a. m....	718.2	18.2	51	w.	4.5	2165	590.8	5.4	......	nw.	....
10:25 a. m....	718.3	18.2	48	w.	8.5	1560	635.5	8.7	......	nw.	....
10:32 a. m....	718.3	18.6	50	w.	8.5	1105	670.9	10.5	......	nw.	....
10:38 a. m....	718.3	18.6	49	w.	5.8	526	718.3	18.6	49	w.	5.8
May 20.											
6:36 a. m....	717.4	15.3	61	s.	5.8	526	717.4	15.3	61	s.	5.8
6:45 a. m....	717.4	15.7	61	s.	5.4	818	693.3	16.4	......	s.	....
7:01 a. m....	717.4	16.0	61	s.	5.4	1296	654.4	11.9	......	ssw.	....
7:12 a. m....	717.4	15.4	62	s.	4.5	1867	611.4	7.8	......	ssw.	....
7:38 a. m....	717.3	15.8	65	s.	4.9	2162	590.0	6.5	......	sw.	....
7:50 a. m....	717.3	15.8	65	s.	5.4	2700	552.4	3.4	......	sw.	....
8:14 a. m....	717.2	15.7	70	s.	5.8	3294	513.2	0.3	......	sw.	....
8:31 a. m....	717.1	15.9	68	ssc.	6.3	3566	495.7	− 2.4	......	sw.	....
9:44 a. m....	717.0	15.6	81	s.	8.0	4747	426.8	− 8.0	......	sw.	....
10:40 a. m....	717.0	15.2	84	s.	5.4	3899	475.2	− 3.5	......	sw.	....
10:57 a. m....	717.0	14.6	82	s.	5.4	3218	516.9	− 1.4	......	wsw.	....
11:23 a. m....	716.8	14.4	96	sse.	6.7	2526	562.6	0.7	......	s.	....
12:03 p. m....	716.5	14.2	100	sse.	8.0	1286	654.4	9.7	......	s.	....
12:36 p. m....	716.2	14.7	100	sse.	7.2	526	716.2	14.7	100	sse.	7.2

May 18.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 8000 m., at maximum altitude.

8/10 to 3/10 St.-Cu. from the west-northwest.

An area of low pressure was central east of Lake Huron. A high pressure area was central in Arkansas.

May 19.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 6800 m.; at maximum altitude, 5000 m.

There were a few Cu. from the northwest after 9:52 a. m.

Pressure was low over New Brunswick, and high over Virginia and the Carolinas.

May 20.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 8500 m.; at maximum altitude, 7900 m.

9/10 Ci.-St. from the west, accompanied by a solar halo, were observed until 9 a. m., when lower clouds began to form, and the halo was obscured. Light rain began at 9:55 a. m. and dense fog at 11:30 a. m.

An area of low pressure, central over Kansas, covered most of the United States east of the Rocky Mountains. A high pressure area was central off the North Carolina coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. May 21.	*mm.*	°*C.*	%		*m. p. s.*	*m.*	*mm.*	°*C.*	%		*m. p. s.*
3:31 p. m....	714.4	22.4	76	ssw.	3.6	526	714.4	22.4	76	ssw.	3.6
3:41 p. m....	714.4	22.4	76	sw.	3.6	1629	628.3	14.8	......	wnw.	......
4:01 p. m....	714.3	23.2	72	sse.	2.7	1273	655.1	15.7	......	w.	......
4:22 p. m....	714.3	23.6	70	s.	3.6	1014	675.2	17.6	......	w.	......
4:29 p. m....	714.3	23.6	72	se.	3.6	526	714.3	23.6	72	se.	3.6
May 22.											
8:58 a. m....	717.3	20.8	79	se.	4.0	526	717.3	20.8	79	se.	4.0
9:12 a. m....	717.3	21.4	80	e.	5.4	1945	607.5	11.5	......	wsw.	......
9:31 a. m....	717.3	20.6	81	e.	4.0	1596	633.0	13.5	......	sw.	......
9:44 a. m....	717.3	21.2	82	ese.	......	1125	......	......	......	calm.	......
9:51 a. m....	717.3	21.2	81	se.	5.4	1109	670.6	18.7	......	se.	......
9:57 a. m....	717.3	21.4	78	ese.	4.9	526	717.3	21.4	78	ese.	4.9
May 23.											
1:21 p. m....	713.3	18.7	98	s.	8.0	526	713.3	18.7	98	s.	8.0
1:31 p. m....	713.2	19.2	96	s.	7.6	907	682.3	17.7	......	ssw.	......
1:41 p. m....	713.1	19.9	94	s.	7.2	1344	648.4	17.2	......	sw.	......
3:04 p. m....	712.4	22.3	84	s.	10.7	1870	609.6	15.2	......	sw.	......
3:18 p. m....	712.2	22.6	84	s.	10.7	2862	541.8	10.2	......	wsw.	......
3:31 p. m....	712.0	23.1	81	s.	8.9	3101	525.9	7.3	......	wsw.	......
4:00 p. m....	711.7	24.0	79	s.	9.8	3537	499.0	6.3	......	wsw.	......
4:25 p. m....	711.6	23.8	82	s.	9.4	3846	480.4	3.4	......	w.	......
5:16 p. m....	711.5	23.4	84	s.	7.2	3093	525.9	6.4	......	w.	......
5:39 p. m....	711.4	23.4	68	s.	7.6	1940	603.6	13.8	......	sw.	......
5:50 p. m....	711.4	23.2	68	s.	5.4	1205	657.7	18.0	......	ssw.	......
6:00 p. m....	711.4	23.2	70	s.	5.4	911	680.6	20.4	......	s.	......
6:04 p. m....	711.4	23.3	69	s.	5.4	526	711.4	23.3	69	s.	5.4
May 24.											
10:12 a. m....	712.0	22.5	80	se.	7.2	526	712.0	22.5	80	se.	7.2
10:32 a. m....	711.9	22.6	74	se.	5.4	770	692.2	19.7	......	s.	......
10:43 a. m....	711.8	23.1	72	sse.	8.0	1102	666.3	19.8	......	s.	......
11:00 a. m....	711.7	23.4	71	sse.	5.4	2033	597.3	13.3	......	sw.	......
11:17 a. m....	711.6	24.0	71	sse.	8.0	2750	548.1	7.7	......	sw.	......
11:41 a. m....	711.4	24.3	70	s.	4.5	3387	507.0	2.4	......	sw.	......
12:13 p. m....	711.1	23.7	70	s.	6.3	4046	467.1	− 1.1	......	sw.	......
1:02 p. m....	710.6	24.9	74	s.	7.2	3174	520.1	4.5	......	ssw.	......
1:42 p. m....	710.0	24.5	66	s.	9.8	2525	562.0	9.2	......	ssw.	......
2:13 p. m....	709.6	24.6	61	s.	10.3	1949	601.6	13.5	......	sw.	......
2:34 p. m ...	709.4	24.4	69	ssw.	6.3	1360	644.3	16.6	......	ssw.	......
2:56 p. m....	709.2	25.2	64	s.	9.4	889	680.4	20.6	......	s.	......
3:04 p. m....	709.2	24.6	64	s.	9.8	526	709.2	24.6	64	s.	9.8

May 21.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2200 m.
There were 8/10 Cu. from the west-northwest.
Low pressure, central over Oklahoma, extended northeastward to Lake Ontario.

May 22.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2200 m.
Ci. from the southwest, diminished from 8/10 to 4/10. St. from the east-southeast appeared at 9:30 a. m. and increased to 3/10 by the end of the ascension.
Pressure was low over the Mississippi Valley and high over New England.

May 23.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 7500 m.; at maximum altitude, 6900 m.
There were from 4/10 to 8/10 clouds consisting of Ci.-Cu. from the west, and low St. from the south-southwest. The St. passed under the kites at intervals from 1:25 to 4 p. m.
Pressure was low over Indiana and high off the New England coast.

May 24.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 6000 m.; at maximum altitude, 5800 m.
6/10 A.-St. from the southwest, and from few to 2/10 cu. from the south to southwest were observed during the flight. Light rain from 12:16 p. m. to 12:21 p. m.
An extensive area of low pressure, with centers over Tennessee, Lake Superior, and Quebec, covered the United States east of the Mississippi River.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
May 25.	*mm.*	*° C.*	*%*		*m. p. s.*	*m.*	*mm.*	*° C.*	*%*		*m. p. s.*
11:13 a. m....	709.9	18.8	91	s.	4.9	526	709.9	18.8	91	s.	4.9
11:30 a. m....	709.8	19.1	88	s.	5.4	708	694.9	15.3	......	s.	....
12:17 p. m....	709.4	20.4	81	s.	6.7	895	679.7	17.6	......	ssw.	....
12:42 p. m....	709.2	20.3	79	s.	7.2	1429	637.9	11.6	......	ssw.	....
1:05 p. m....	709.0	20.6	80	s.	6.7	2806	540.9	5.2	......	sw.	....
1:15 p. m....	709.0	20.3	79	s.	8.0	3225	513.7	2.0	......	sw.	....
1:58 p. m....	709.2	21.2	75	s.	6.3	2741	545.5	5.4	......	sw.	....
2:23 p. m....	709.2	21.6	71	s.	6.7	2050	593.0	9.8	......	sw.	....
2:33 p. m....	709.2	21.4	73	s.	5.4	1284	649.2	14.0	......	ssw.	....
2:39 p. m....	709.2	21.2	75	w.	10.3	526	709.2	21.2	75	w.	10.3
May 26.											
8:36 a. m....	714.9	13.6	77	nw.	11.2	526	714.9	13.6	77	nw.	11.2
8:47 a. m....	715.0	14.0	72	wnw.	12.5	840	689.0	11.6	......	wnw.	....
9:00 a. m....	715.2	14.4	74	nw.	10.3	1182	661.4	9.0	......	nw.	....
9:33 a. m....	715.4	15.1	67	nw.	8.9	1677	623.3	6.1	......	wnw.	....
10:32 a. m....	715.6	16.2	59	nw.	6.3	2153	588.4	2.1	......	w.	....
10:55 a. m....	715.7	16.6	61	nw.	8.9	1769	616.9	5.5	......	w.	....
11:06 a. m....	715.7	16.0	63	nw.	8.0	1190	661.4	8.9	......	w.	....
11:16 a. m....	715.7	15.6	67	nw.	7.2	765	695.8	12.4	......	wnw.	....
11:22 a. m....	715.7	15.6	65	wnw.	6.7	526	715.7	15.6	65	wnw.	6.7
May 27.											
6:55 a. m....	720.5	8.5	72	nw.	8.9	526	720.5	8.5	72	nw.	8.9
7:05 a. m....	720.5	8.8	70	nw.	10.7	830	694.4	5.6	......	nw.	....
7:13 a. m....	720.5	8.9	72	nw.	10.3	1292	656.0	2.8	......	wnw.	....
7:26 a. m....	720.5	9.2	67	nw.	7.6	1788	617.2	− 0.2	......	wnw.	....
7:39 a. m....	720.6	9.6	66	nw.	10.7	2134	591.3	− 2.2	......	nw.	....
8:04 a. m....	720.6	10.0	66	nw.	13.0	2209	585.8	0.4	......	nw.	....
8:27 a. m....	720.6	10.3	61	nw.	13.0	2441	569.2	− 1.0	......	nw.	....
8:52 a. m....	720.7	10.5	62	nw.	12.5	3681	486.4	− 8.9	......	nw.	....
9:15 a. m....	720.7	11.1	60	nw.	13.9	4438	441.8	−14.2	......	nw.	....
9:42 a. m....	720.7	12.2	56	nw.	12.5	3634	490.1	− 7.4	......	nw.	....
10:03 a. m....	720.7	11.7	58	nw.	16.1	3076	526.2	− 4.1	......	nw.	....
10:43 a. m....	720.8	12.4	58	nw.	11.6	2390	573.8	1.0	......	nw.	....
10:48 a. m....	720.8	12.7	55	nw.	12.1	2223	585.8	1.8	......	nw.	....
10:53 a. m....	720.8	12.6	57	nw.	11.6	2015	601.2	0.6	......	nw.	....
11:00 a. m....	720.8	12.6	53	nw.	13.4	1732	622.6	1.5	......	nw.	....
11:14 a. m....	720.8	12.2	56	nw.	9.8	1282	657.8	3.7	......	nw.	....
11:27 a. m....	720.8	13.1	50	nw.	11.6	837	694.4	7.7	......	nw.	....
11:34 a. m....	720.8	13.8	53	nw.	11.6	526	720.8	13.8	53	nw.	11.6

May 25.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 4000 m., at maximum altitude.

From 1/10 to 2/10 A.-Cu. and from 6/10 to 7/10 Cu. and St.-Cu. from the southwest were present. The base of the St.-Cu. was about 700 m. above sea level. Light rain fell from 10:05 a. m. to 10:20 a. m. and from 3:46 to 4:35 p. m.

An area of low pressure, central over the St. Lawrence Valley, extended southwestward to Florida.

May 26.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 4600 m.; at maximum altitude, 3800 m.

Cu., from the west, increased from few at 10 a. m. to 8/10; altitude of cloud base, about 1750 m.

Low pressure was central over the lower St. Lawrence. Pressure was high over the Mississippi Valley.

May 27.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 7590 m.; at maximum altitude, 7200 m.

Cloudless at the beginning of the flight, from a few to 2/10 Cu. from the northwest, after 8:00 a. m.

A high pressure area, central over Lake Michigan, extended over most of the United States east of the Mississippi River. Low pressure was central off the New Brunswick coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
May 28.	*mm.*	*° C.*	%		*m. p. s.*	*m.*	*mm.*	*° C.*	%		*m. p. s.*
6:41 a. m....	723.1	9.1	70	nw.	9.8	526	723.1	9.1	70	nw.	9.8
6:49 a. m....	723.2	9.2	70	nw.	11.6	860	694.7	9.2	......	nw.	....
6:59 a. m....	723.2	9.6	68	nw.	12.5	1253	662.5	8.6	......	nnw.	....
7:14 a. m....	723.2	9.8	69	nw.	11.6	1724	625.7	5.1	......	n.	....
8:26 a. m....	723.5	12.0	65	nw.	10.3	2286	584.6	1.0	......	nne.	....
8:30 a. m....	723.5	12.0	64	nw.	10.3	2501	569.0	1.1	......	nne.	....
8:37 a. m....	723.5	12.6	63	nw.	10.7	3534	500.2	− 3.0	......	nne.	....
8:40 a. m....	723.6	12.7	62	nw.	10.7	3653	492.8	− 3.0	......	nne.	....
8:54 a. m....	723.7	13.2	63	nw.	9.4	4096	466.2	− 4.8	......	n.	....
9:15 a. m....	723.7	13.6	60	nw.	9.8	3691	490.9	− 2.8		n.	....
9:25 a. m....	723.7	14.1	57	nw.	10.7	3487	503.9	− 3.5	......	n.	....
9:58 a. m....	723.8	14.9	53	nw.	11.6	3334	514.0	− 0.4	......	n.	....
10:03 a. m....	723.8	15.0	53	nw.	12.1	3218	521.4	− 0.6	......	n.	....
10:17 a. m....	723.8	14.9	53	nw.	10.3	2634	560.7	1.8	......	n.	....
10:20 a. m....	723.8	15.1	53	nw.	10.7	2556	566.3	1.1	......	n.	....
10:31 a. m....	723.9	15.4	53	nw.	9.4	1850	617.8	5.6	......	n.	....
10:46 a. m....	723.9	16.0	55	nw.	9.4	1465	647.3	8.5	......	nnw.	....
10:56 a. m....	723.9	16.3	52	nw.	8.5	1089	677.2	10.5	......	nnw.	....
11:17 a. m....	723.9	16.0	51	nw.	8.5	526	723.9	16.0	51	nw.	8.5
May 29.											
9:31 a. m....	718.3	19.4	52	s.	1.8	526	718.3	19.4	52	s.	1.8
9:41 a. m....	718.2	18.9	55	wnw.	1.8	1840	615.5	12.4	......	wnw.	....
10:11 a. m....	717.9	20.7	53	se.	4.9	1296	656.1	13.6	......	w.	....
10:25 a. m....	717.7	21.1	47	s.	4.9	1010	678.6	16.2	......	s.	....
10:30 a. m....	717.7	21.4	46	ssw.	5.4	526	717.7	21.4	46	ssw.	5.4

May 28.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 6360 m.; at maximum altitude, 6160 m.

There were a few Ci. at the beginning of the flight and a few Cu. at its close. The direction could not be determined.

A well-developed high, central over Ohio, covered the States east of the Mississippi. Pressure was low off the New England coast.

May 29.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2500 m.

A few Ci.—direction not apparent—were visible.

At 8 a. m. pressure was high over the east Gulf States and low over the upper Lake region.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
May 30.	*mm.*	*° C.*	%		*m. p. s.*	*m.*	*mm.*	*° C.*	%		*m. p. s.*
7:09 a. m....	708.6	14.1	76	wnw.	10.7	526	708.6	14.1	76	wnw.	10.7
7:17 a. m....	708.6	14.1	77	wnw.	9.4	884	679.1	11.9	......	w.	....
7:27 a. m....	708.6	14.2	79	wnw.	8.5	1239	650.7	8.4	......	w.	....
7:40 a. m....	708.7	14.0	79	wnw.	7.6	1772	609.9	3.9	......	w.	....
8:06 a. m....	708.7	14.2	77	wnw.	7.6	2455	560.7	− 0.4	......	w.	....
8:45 a. m....	708.7	14.7	73	wnw.	5.4	3020	522.5	− 0.6	......	wnw.	....
9:22 a. m....	708.6	15.1	67	wnw.	5.4	3743	477.0	− 4.1	......	wnw.	....
10:14 a. m....	708.3	15.8	60	w.	8.9	3051	520.6	− 1.8	......	w.	....
10:23 a. m....	708.2	15.7	59	w.	8.5	2964	526.2	− 3.4	......	w.	....
10:44 a. m....	707.9	15.6	59	w.	7.2	2279	572.6	0.4	......	w.	....
10:57 a. m....	707.8	15.9	59	w.	8.0	1894	600.3	2.5	......	w.	....
11:12 a. m....	707.8	15.9	58	w.	8.5	1309	644.7	7.9	......	w.	....
11:22 a. m....	707.7	15.6	58	w.	7.2	874	679.1	11.4	......	w.	....
11:28 a. m....	707.7	15.8	58	w.	7.2	526	707.7	15.8	58	w.	7.2
May 31.											
7:19 a. m....	705.1	7.1	83	nw.	6.3	526	705.1	7.1	83	nw.	6.3
7:26 a. m....	705.1	7.1	83	nw.	7.2	815	680.6	4.1	......	w.	....
7:43 a. m....	705.1	7.5	84	wnw.	8.0	1256	644.5	0.4	......	w.	....
8:11 a. m....	705.1	7.8	82	wnw.	8.0	1892	595.7	− 1.9	......	w.	....
8:26 a. m....	705.1	8.2	80	wnw.	9.4	2354	562.2	− 4.1	......	w.	....
8:50 a. m....	705.1	8.5	74	wnw.	10.3	2900	524.0	− 6.1	......	w.	....
9:33 a. m....	705.1	9.1	72	wnw.	10.3	3461	487.8	− 8.3	......	w.	....
10:22 a. m....	705.1	8.6	78	wnw.	7.6	2899	524.0	− 6.7	......	w.	....
11:10 a. m....	705.0	9.3	71	wnw.	8.5	2121	578.5	− 3.0	......	w.	....
11:14 a. m....	705.0	9.5	71	wnw.	8.5	2046	584.0	− 3.8	......	w.	....
11:19 a. m....	705.0	9.3	67	wnw.	6.7	1611	616.9	− 1.8	......	w.	....
11:29 a. m....	705.0	9.1	71	wnw.	8.0	1090	657.7	− 0.2	......	w.	....
11:50 a. m....	705.1	9.2	65	wnw.	8.0	716	689.0	4.8	......	wnw.	....
11:55 a. m....	705.1	9.8	63	wnw.	9.8	526	705.1	9.8	63	wnw.	9.8

May 30.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 7000 m.; at maximum altitude, 6600 m.

There were 8/10 to 10/10 Ci.-St. and A.-St. from the west. A solar halo was observed. There were also a few St.-Cu. from the west at an altitude of about 3000 m.

At 8 a. m. pressure was low over the North Atlantic States and the lower Lake region and relatively high over Louisiana.

May 31.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 7000 m., at maximum altitude.

There were 1/10 to 3/10 A.-St. from the west and 6/10 to 8/10 St.-Cu. from the west during the flight.

An area of low pressure was central off the coast of Massachusetts, and an area of high pressure over northern Texas.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m. Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	At different heights above sea. Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. June 1.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
7:04 a. m.	704.5	5.8	76	w.	8.5	526	704.5	5.8	76	w.	8.5
7:13 a. m.	704.5	5.9	75	w.	8.9	809	680.3	1.8	......	wnw.	....
7:19 a. m.	704.5	6.0	75	w.	8.9	1065	659.1	1.0	......	wnw.	....
9:25 a. m.	704.5	8.0	68	wnw.	9.8	1228	645.9	1.4	......	wnw.	....
10:02 a. m.	704.7	9.2	65	wnw.	11.2	2511	549.9	−6.1	......	wnw.	....
10:04 a. m.	704.7	9.5	65	wnw.	11.2	2632	541.5	−5.1	......	wnw.	....
10:17 a. m.	704.8	9.5	64	wnw.	9.4	3168	506.9	−5.8	......	wnw.	....
10:38 a. m.	705.0	8.8	67	w.	8.5	2621	543.4	−3.8	......	wnw.	....
10:45 a. m.	705.0	8.7	67	w.	7.2	2526	549.9	−5.3	......	wnw.	....
10:55 a. m.	705.1	8.7	67	wnw.	7.2	1621	616.6	−0.8	......	wnw.	....
11:11 a. m.	705.1	9.0	66	w.	6.3	1538	623.0	1.7	......	w.	....
11:20 a. m.	705.1	9.4	68	wnw.	6.7	904	673.3	2.8	......	wnw.	....
11:25 a. m.	705.1	9.6	66	nw.	6.3	659	693.8	5.9	......	wnw.	....
11:28 a. m.	705.1	9.5	66	wnw.	6.3	526	705.1	9.5	66	wnw.	6.3
June 2.											
8:00 a. m.	708.2	11.5	64	wnw.	8.9	526	708.2	11.5	64	wnw.	8.9
8:12 a. m.	708.3	11.9	64	wnw.	8.0	894	677.7	8.6	......	wnw.	....
8:30 a. m.	708.3	11.6	64	wnw.	8.0	1468	631.9	4.0	......	wnw.	....
8:42 a. m.	708.3	11.8	64	wnw.	7.6	1905	598.8	1.1	......	wnw.	....
8:55 a. m.	708.3	11.9	64	wnw.	7.6	2365	565.5	−2.0	......	nw.	....
9:04 a. m.	708.3	12.8	61	wnw.	6.3	2456	559.1	−0.5	......	nw.	....
9:19 a. m.	708.3	13.9	54	wnw.	9.4	2788	536.8	−1.3	......	nw.	....
9:46 a. m.	708.4	14.4	48	wnw.	11.6	3812	471.7	−6.2	......	nw.	....
10:14 a. m.	708.4	15.2	43	wnw.	8.9	4204	449.0	−9.0	......	nw.	....
10:54 a. m.	708.4	16.3	38	wnw.	10.7	3585	486.6	−7.3	......	nw.	....
11:40 a. m.	708.3	17.5	37	wnw.	9.3	3281	506.0	−4.4	......	nw.	....
11:50 a. m.	708.2	17.1	39	wnw.	13.4	2865	533.1	−3.2	......	w.	....
12:12 p. m.	708.1	18.4	40	wnw.	13.4	2009	592.7	3.1	......	wnw.	....
12:30 p. m.	708.0	18.2	34	wnw.	12.5	1334	643.3	9.0	......	wnw.	....
12:40 p. m.	708.0	18.6	34	wnw.	10.7	965	672.4	13.3	......	wnw.	....
12:48 p. m.	708.0	18.8	34	wnw.	8.9	526	708.0	18.8	34	wnw.	8.9
June 3.											
1:35 p. m.	710.8	8.7	88	wnw.	16.1	526	710.8	8.7	88	wnw.	16.1
1:44 p. m.	711.1	8.8	88	wnw.	14.8	866	....	5.8	......	nnw.	....
1:55 p. m.	711.1	9.1	87	wnw.	15.2	1158	....	5.4	......	nnw.	....
2:03 p. m.	711.2	9.4	85	wnw.	15.6	1292	....	3.9	......	n.	....
2:20 p. m.	711.6	10.8	......	wnw.	14.8	526	....	10.8	......	wnw.	14.8

June 1.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 5250 m.; at maximum altitude, 4100 m.

There were 8/10 to 10/10 St.-Cu., from the west. The head kite was obscured by St.-Cu. from 9:53 to 11:11 a. m.

Low pressure, central over the St. Lawrence Valley, covered the eastern United States.

June 2.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 7500 m.; a maximum altitude, 7200 m.

There were 1/10 A.-Cu. and 2/10 to 3/10 St.-Cu. from the northwest. The base of the St.-Cu. was about 2000 m. above sea level.

Low pressure was central over the St. Lawrence Valley. Pressure was relatively high over Florida.

June 3.—Two kites were used; lifting surface, 10.8 sq. m. Wire out, 2400 m. at maximum altitude.

There were 10/10 St. from the north.

A high was central over Lake Superior. There were areas of low pressure central east of Delaware and over the lower St. Lawrence

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910.											
June 4.	*mm.*	*° C.*	%		*m. p. s.*	*m.*	*mm.*	*° C.*	%		*m. p. s.*
10:17 a. m.	720.3	12.8	63	n.	3.1	526	720.3	12.8	63	n.	3.1
10:39 a. m.	720.1	13.8	56	n.	....	1958	606.3	8.8	......	wnw.	....
10:52 a. m.	720.1	12.9	58	wsw.	3.6	1575	634.8	10.0	......	w.	....
11:07 a. m.	720.0	13.3	58	wnw.	3.1	1049	676.3	8.2	......	wnw.	....
11:20 a. m.	719.9	13.6	64	nnw.	3.6	526	719.9	13.6	64	nnw.	3.6
June 5.											
2:04 p. m.	712.1	13.4	100	sse.	5.4	526	712.1	13.4	100	sse.	5.4
2:13 p. m.	712.0	13.4	100	s.	5.8	881	682.7	12.4	......	s.	....
2:36 p. m.	711.7	13.5	100	sse.	5.4	1408	641.0	13.1	......	sw.	....
2:57 p. m.	711.5	13.6	100	sse.	5.8	1854	607.7	10.7	......	wsw.	....
3:13 p. m.	711.4	13.8	100	s.	5.4	2490	562.6	6.1	......	wsw.	....
4:11 p. m.	711.1	14.4	100	s.	6.3	3286	509.4	2.2	......	wsw.	....
4:46 p. m.	710.8	14.6	100	sse.	5.8	2681	548.7	5.0	......	wsw.	....
5:21 p. m.	710.7	15.0	100	s.	6.3	1974	597.9	8.7	......	wsw.	....
5:38 p. m.	710.7	15.0	100	s.	6.3	1450	637.1	12.6	......	wsw.	....
5:56 p. m.	710.7	15.2	100	ssw.	7.2	909	679.3	14.3	......	sw.	....
6:05 p. m.	710.7	15.2	100	ssw.	7.2	526	710.7	15.2	100	ssw.	7.2
June 6.											
8:38 a. m.	712.5	16.0	76	nw.	8.9	526	712.5	16.0	76	nw.	8.9
8:47 a. m.	712.5	15.8	75	nw.	9.4	770	692.3	13.2	......	nw.	....
9:05 a. m.	712.6	16.4	75	nw.	8.5	1308	649.5	10.3	......	nw.	....
9:18 a. m.	712.7	16.5	76	wnw.	7.6	1742	616.6	7.7	......	wnw.	....
9:23 a. m.	712.8	16.5	75	w.	7.6	2086	591.7	8.6	......	w.	....
9:40 a. m.	712.9	16.8	73	wnw.	7.6	2734	547.0	5.4	......	w.	....
10:08 a. m.	713.0	17.3	72	wnw.	8.9	3124	521.7	3.3	......	w.	....
10:31 a. m.	713.0	17.8	68	nw.	9.8	3796	479.9	−0.5	......	w.	....
11:23 a. m.	713.0	18.9	64	wnw.	7.2	4376	446.1	−4.5	......	wsw.	....
12:12 p. m.	712.9	19.5	58	wnw.	7.6	3576	493.0	−0.2	......	w.	....
13:33 p. m.	712.9	19.6	56	w.	8.0	2369	571.9	6.8	......	w.	....
12:36 p. m.	712.9	19.7	53	w.	7.2	1907	605.1	5.8	......	w.	....
12:52 p. m.	712.9	19.9	52	w.	6.7	1241	655.5	11.9	......	w.	....
1:00 p. m.	712.9	20.2	52	w.	5.4	862	685.6	16.0	......	w.	....
1:08 p. m.	712.9	20.3	52	sw.	4.9	526	712.9	20.3	52	sw.	4.9

June 4.—One balloon was used; capacity, 31.1 cu. m. Wire our, 2000 m.
The sky was cloudless.
High pressure, central over Ontario, covered the eastern United States.

June 5.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 6000 m.; at maximum altitude, 4850 m.
Light rain and dense fog at the beginning. Rain ended at 3.00 p. m. and the fog continued.
Low pressure was central over Ohio. Pressure was high over New Brunswick.

June 6.—Four kites were used; lifting surface, 32.0 sq. m. Wire out, 7500 m.; at maximum altitude, 6500 sq. m.
There were from 3/10 to 6/10 Ci. from the west and Cu. from the west-northwest.
Centers of low pressure lay over the Lake region and off the New Jersey coast. Pressure was high over the Mississippi Valley.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
June 7.	mm.	° C.	%		m. p. s.	m.	mm.	° C.	%		m. p. s.
6:55 a. m....	714.2	12.5	82	nw.	11.2	526	714.2	12.5	82	nw.	11.2
7:02 a. m....	714.2	12.8	80	nw.	10.7	834	688.5	10.4	......	nw.	....
7:12 a. m....	714.2	13.0	78	nw.	11.2	1245	655.1	7.3	......	nw.	....
7:27 a. m....	714.2	13.0	75	nw.	11.6	1703	619.8	4.5	......	wnw.	....
7:32 a. m....	714.2	13.0	75	nw.	11.6	1986	598.6	4.1	......	wnw.	....
7:40 a. m....	714.2	13.0	75	nw.	11.6	2285	577.0	4.8	......	wnw.	....
7:55 a. m....	714.2	13.1	76	nw.	11.6	2996	528.8	2.0	......	wnw.	....
9:05 a. m....	714.4	13.5	70	nw.	15.2	3746	481.4	−4.6	......	wnw.	....
10:12 a. m....	714.1	14.0	63	wnw.	14.3	2655	551.2	2.8	......	wnw.	....
10:50 a. m....	714.7	13.8	58	nw.	17.9	1730	618.0	5.5	......	wnw.	....
11:02 a. m....	714.8	14.1	55	nw.	13.4	1678	622.1	3.3	......	wnw.	....
11:18 a. m....	714.9	14.6	51	nw.	12.5	1139	664.3	6.4	......	nw.	....
11:37 a. m....	715.1	14.6	50	nw.	13.4	865	686.9	9.8	......	nw.	....
11:52 a. m....	715.2	14.6	50	nw.	17.9	526	715.2	14.6	50	nw.	17.9
June 8.											
6:57 a. m....	719.6	10.4	69	nw.	8.0	526	719.6	10.4	69	nw.	8.0
7:15 a. m....	719.6	10.8	66	nw.	7.6	793	697.0	10.4	......	nnw.	....
7:28 a. m....	719.6	11.0	67	wnw.	8.9	1192	664.3	8.9	......	n.	....
7:44 a. m....	719.6	11.8	70	wnw.	7.6	1717	623.4	6.2	......	n.	....
9:18 a. m....	719.9	14.4	56	nw.	6.3	2265	583.9	4.1	......	n.	....
9:20 a. m....	719.9	14.5	58	nnw.	5.8	2489	568.1	5.7	......	n.	....
9:30 a. m....	719.9	14.4	57	nw.	6.3	2847	543.8	4.0	......	n.	....
9:32 a. m....	719.9	14.5	56	nw.	6.3	2665	556.0	4.5	......	n.	....
9:36 a. m....	719.9	14.6	58	nw.	6.3	2372	576.4	3.6	......	n.	....
10:07 a. m....	720.0	15.6	52	nw.	5.8	1861	613.7	6.0	......	n.	....
10:25 a. m....	719.9	15.5	52	nw.	6.3	1180	666.0	9.6	......	n.	....
10:40 a. m....	719.8	16.0	52	nnw.	5.4	526	719.8	16.0	52	nnw.	5.4
June 9.											
8:00 a. m....	717.9	13.8	76	se.	5.4	526	717.9	13.8	76	se.	5.4
8:12 a. m....	717.9	13.7	76	se.	5.8	820	693.4	13.8	......	s.	....
9:49 a. m....	717.6	13.8	87	se.	8.9	694	703.6	16.7	......	s.	....
10:29 a. m....	717.6	12.9	90	se.	8.0	1223	660.4	11.2	......	s.	....
10:35 a. m....	717.6	12.9	90	se.	9.4	1558	634.1	7.9	......	s.	....
10:43 a. m....	717.6	12.6	93	se.	9.8	2302	579.5	5.8	......	ssw.	....
11:03 a. m....	717.6	12.5	95	se.	8.0	2034	598.5	6.2	......	ssw.	....
11:32 a. m....	717.6	12.7	99	se.	8.5	1822	614.3	7.8	......	ssw.	....
11:45 a. m....	717.6	12.8	100	se.	8.9	1464	641.6	10.0	......	s.	....
11:55 a. m....	717.6	12.8	100	se.	8.0	1002	678.2	11.5	......	s.	....
12:03 p. m....	717.6	13.0	100	se.	8.5	794	695.1	11.8	......	se.	....
12:07 p. m....	717.5	13.0	100	se.	8.5	526	717.5	13.0	100	se.	8.5

June 7.—Four kites were used; lifting surface, 25.2 sq. Wire out, 7500 m.; at maximum altitude, 7000 m.

There were about 3/10 St.-Cu. from the west-northwest. The base of the clouds was about 1500 m. above sea level.

High pressure was central over Iowa. Pressure was low over the New England States.

June 8.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 5500 m.; at maximum altitude, 3800 m.

Ci.-St. from the west increased from few to 7/10 during the flight. A solar halo was observed from 9:42 a. m. to the end of the flight.

Pressure was high over the Ohio Valley and Lake region and low over New Brunswick.

June 9.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 4500 m., at maximum altitude.

There were 9/10 St.-Cu. from the west-southwest. These increased to 10/10 by 9:17 a. m. Low St. from the south appearing at 9:56 covered the sky by 11:12 a. m. Light fog began at 11:27 and dense fog at 11:43 a. m. Rain fell from 10:29 to 11:52 a. m.

Pressure was high over the upper Lakes and the middle Atlantic coast and comparatively low over Tennessee.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
June 10.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
3:45 p. m.	714.0	12.2	100	e.	6.7	526	714.0	12.2	100	e.	6.7
3:57 p. m.	713.9	12.2	100	e.	6.3	847	687.0	9.5	......	e.	....
4:07 p. m.	713.9	12.2	100	e.	6.3	930	680.2	9.3	......	e.	....
4:17 p. m.	713.8	12.2	100	e.	6.7	1013	673.2	8.0	......	e.	....
4:40 p. m.	713.7	12.2	100	e.	8.5	526	713.7	12.2	100	e.	8.5
June 11.											
1:31 p. m.	714.8	13.6	100	se.	7.2	526	714.8	13.6	100	se.	7.2
1:40 p. m.	714.8	13.8	100	se.	7.6	876	686.1	16.9	......	sw.	....
1:55 p. m.	714.8	14.5	100	se.	7.2	1212	659.4	13.8	......	sw.	....
2:18 p. m.	714.8	14.2	100	se.	7.2	1772	617.1	12.4	......	sw.	....
2:56 p. m.	714.8	14.9	100	se.	7.2	2399	572.4	8.2	......	sw.	....
3:12 p. m.	714.8	15.3	100	se.	7.6	2120	592.2	9.9	......	sw.	....
3:24 p. m.	714.8	15.7	96	se.	6.3	1750	618.9	11.5	......	sw.	....
3:33 p. m.	714.8	16.0	96	se.	7.6	1217	659.4	14.9	......	sw.	....
3:43 p. m.	714.8	16.0	98	se.	8.5	899	684.4	18.2	......	ssw.	....
3:58 p. m.	714.8	15.6	100	s.	6.7	526	714.8	15.6	100	s.	6.7
June 12.											
2:16 p. m.	717.5	15.2	98	nw.	6.7	526	717.5	15.2	98	nw.	6.7
2:27 p. m.	717.6	15.1	100	nw.	7.2	777	696.7	12.9	......	nw.	....
3:52 p. m.	718.0	15.4	96	nw.	5.8	935	684.3	14.7	......	nw.	....
4:50 p. m.	718.3	15.2	96	wnw.	6.7	743	700.1	13.1	......	nw.	....
5:00 p. m.	718.3	15.0	92	nw.	6.7	526	718.3	15.0	92	nw.	6.7
June 13.											
2:02 p. m.	720.9	14.9	89	nw.	1.8	526	720.9	14.9	89	nw.	1.8
2:25 p. m.	720.7	15.4	90	nw.	1.3	2422	575.6	11.8	......	calm.	....
2:53 p. m.	720.5	15.6	87	nw.	1.8	1873	614.3	12.0	......	calm.	....
2:59 p. m.	720.4	15.5	86	nw.	1.8	1607	633.9	14.2	......	calm.	....
3:12 p. m.	720.3	15.6	89	n.	1.3	940	685.9	12.9	......	e.	....
3:22 p. m.	720.3	16.0	89	nnw.	2.2	526	720.3	16.0	89	nnw.	2.2

June 10.—Two kites were used; lifting surface, 13.1 sq. m. Wire out, 1200 m., at maximum altitude.

There were 10/10 St. from the east and light fog, the fog changing to dense by 4:15 p. m. Light rain fell throughout the flight.

At 8 a. m. a well-developed low, accompanied by heavy rains, covered the Gulf and South Atlantic States, its center overlying eastern Tennessee.

June 11.—Two kites were used; lifting surface, 12.6 sq. m. Wire out, 4500 m.; at maximum altitude, 4300 m.

There was dense fog until 3:12 p. m. and light fog, accompanied by 9/10 St. from the southeast thereafter.

Pressure was low over West Virginia and high over the Gulf of St. Lawrence.

June 12.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 2500 m.; at maximum altitude, 2100 m.

There were 10/10 St. from the northwest during the flight. Light rain from the beginning of the flight unti. 2:40 p. m., and from 3:40 p. m. until the end of the flight.

At 8:00 a. m. the pressure was low over Ontario and high over Indiana.

June 13.—One balloon was used; capacity, 31.1 cu. m. Wire out, 1900 m.

St. clouds from the northwest covered the sky.

High pressure, with centers over Iowa and Ohio, covered most of the United States east of the Rocky Mountains. A low was central over the lower St. Lawrence.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
June 14.	*mm.*	*° C.*	%		*m. p. s.*	*m.*	*mm.*	*° C.*	%		*m. p. s.*
3:25 p. m....	718.3	19.4	79	nnw.	1.3	526	718.3	19.4	79	nnw.	1.3
3:50 p. m....	718.1	19.5	78	nnw.	0.9	1238	660.8	14.8	......	calm.	....
3:57 p. m....	718.0	19.5	78	nnw.	1.3	984	680.7	16.0	......	calm.	....
4:04 p. m....	718.0	19.6	78	nnw.	1.3	526	718.0	19.6	78	nnw.	1.3
June 15.											
2:22 p. m....	716.2	20.9	78	se.	2.2	526	716.2	20.9	78	se.	2.2
2:41 p. m....	716.1	20.9	80	se.	2.7	1959	605.2	12.1	......	se.	....
2:52 p. m....	716.0	20.8	81	se.	2.7	1695	624.4	13.3	......	se.	....
3:07 p. m....	716.0	21.0	81	se.	2.7	1238	659.0	15.3	......	calm.	....
3:17 p. m....	715.9	20.7	84	se.	3.1	899	685.7	17.0	......	calm.	....
3:26 p. m....	715.9	20.5	84	se.	3.1	526	715.9	20.5	84	se.	3.1
June 16.											
2:50 p. m....	713.1	18.2	96	sw.	0.9	526	713.1	18.2	96	sw.	0.9
3:15 p. m....	713.1	18.0	96	s.	2.7	1224	656.9	13.6	......	sse.	....
3:45 p. m....	713.1	17.4	98	sw.	3.6	782	692.0	15.8	......	ssw.	....
3:51 p. m....	713.1	17.6	98	wsw.	2.7	526	713.1	17.6	98	wsw.	2.7
June 17.											
8:49 a. m....	715.5	16.6	100	wnw.	8.0	526	715.5	16.6	100	wnw.	8.0
8:57 a. m....	715.5	16.4	99	wnw.	7.6	748	697.1	13.0	......	nw.	....
9:30 a. m....	715.6	16.9	97	wnw.	7.6	1001	676.6	13.9	......	nw.	....
9:38 a. m....	715.5	17.4	95	wnw.	6.3	1520	636.1	11.5	......	nnw.	....
10:20 a. m....	715.6	18.3	88	nw.	6.7	2334	577.1	7.8	......	nnw.	....
10:40 a. m....	715.7	18.7	88	nw.	6.7	2966	534.5	3.3	......	nnw.	....
11:23 a. m....	715.6	19.4	81	nnw.	6.7	3605	494.5	0.5	......	nnw.	....
12:45 p. m....	715.4	21.8	71	nw.	5.8	4353	451.3	− 3.6	......	nnw.	....
1:51 p. m....	715.3	22.4	71	nw.	6.3	3398	508.3	1.9	......	nnw.	....
2:25 p. m....	715.2	22.8	72	nw.	5.4	2611	559.6	7.2	......	nnw.	....
2:51 p. m....	715.1	23.2	72	nw.	5.4	1961	604.8	11.4	......	nnw.	....
3:13 p. m....	715.1	23.8	67	nw.	4.9	1189	662.4	16.0	......	nnw.	....
3:25 p. m....	715.1	24.0	70	nw.	5.4	526	715.1	24.0	70	nw.	5.4

June 14.—One balloon was used; lifting surface, 25.6 cu. m. Wire out, 1200 m.

There were 10/10 St.-Cu. with no apparent motion. The base of the clouds was 1100 m. above sea level.

Low pressure was central over the Gulf of St. Lawrence and pressure was high over eastern Kansas.

June 15.—One balloon was used; capacity, 31.1 cu. m. Wire out, 1840 m.

There were 10/10 St.-Cu. from the southeast, the altitude of their base being about 1700 m.

At 8 a. m. pressure was moderately high over the Mississippi Valley and relatively low off the New England coast.

June 16.—One balloon was used; capacity, 31.1 cu. m. Wire out, 1800 m.

There were 9/10 to 10/10 St. from the south. Light rain began at 3:10 p. m. The balloon was in the clouds at intervals throughout the ascension.

Pressure was low over Virginia and high over Alabama.

June 17.—Seven kites were used; lifting surface, 44.1 sq. m. Wire out, 7500 m.; at maximum altitude, 6200 m.

Low St. from the northwest, altitude about 800 m., covered the sky at the beginning of the flight, but had disappeared by 10 a. m. St.-Cu. from the northwest diminished from 8/10 at 10 a. m. to few at 3 p. m.

High pressure was central over Alabama and New Brunswick and low pressure over the New Jersey coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
June 18.	*mm.*	*°C.*	%		*m. p. s.*	*m.*	*mm.*	*°C.*	%		*m. p. s.*
8:31 a. m.	713.5	21.0	72	wnw.	9.8	526	713.5	21.0	72	wnw.	9.8
8:35 a. m.	713.5	21.0	72	wnw.	9.8	886	684.4	19.0	......	wnw.	....
8:47 a. m.	713.5	21.0	75	wnw.	9.4	1229	657.7	18.1	......	nw.	....
9:01 a. m.	713.4	21.4	77	wnw.	8.0	1657	625.4	14.9	......	nw.	....
9:16 a. m.	713.4	22.0	78	wnw.	8.9	1954	603.9	13.1	......	nw.	....
9:48 a. m.	713.4	22.5	73	wnw.	9.4	2656	556.0	8.3	......	nw.	....
10:45 a. m.	713.2	21.7	76	wnw.	9.4	3728	488.0	0.4	......	nw.	....
11:32 a. m.	713.1	22.5	74	wnw.	10.7	2893	540.1	8.0	......	nw.	....
12:13 p. m.	712.9	22.6	68	wnw.	10.7	1954	603.9	15.2	......	nw.	....
12:27 p. m.	712.8	22.5	68	wnw.	12.5	1522	635.2	18.2	......	nw.	....
12:45 p. m.	712.6	21.8	73	wnw.	12.5	1078	668.6	19.2	......	nw.	....
12:55 p. m.	712.5	21.9	70	wnw.	12.5	812	689.4	19.5	......	nw.	....
1:04 p. m.	712.5	21.8	65	wnw.	13.4	526	712.5	21.8	65	wnw.	13.4
June 19.											
8:28 a. m.	713.1	19.5	87	nw.	8.0	526	713.1	19.5	87	nw.	8.0
8:35 a. m.	713.1	19.6	87	nw.	7.6	819	689.2	16.6	......	nnw.	....
8:48 a. m.	713.2	20.0	85	nw.	8.9	1244	655.8	16.4	......	nnw.	....
8:59 a. m.	713.2	20.2	84	nnw.	10.3	1704	621.2	13.2	......	nnw.	....
9:21 a. m.	713.2	20.8	80	nw.	8.0	2225	584.2	14.4	......	nnw.	....
9:34 a. m.	713.2	21.2	79	nw.	11.2	2855	542.0	10.1	......	nnw.	....
9:50 a. m.	713.2	21.0	80	nw.	8.9	3525	499.9	6.4	......	nnw.	....
10:17 a. m.	713.3	21.4	80	nw.	7.6	4041	469.4	2.5	......	nnw.	....
10:37 a. m.	713.3	22.1	81	nw.	7.2	3356	511.1	7.6	......	nnw.	....
10:57 a. m.	713.4	22.0	79	nw.	8.9	2930	538.2	10.0	......	nnw.	....
11:32 a. m.	713.5	22.4	74	nw.	6.7	1178	661.6	16.4	......	nw.	....
11:40 a. m.	713.5	23.2	71	nw.	6.3	869	685.8	19.0	......	nw.	....
11:45 a. m.	713.6	23.4	71	nw.	6.7	526	713.6	23.4	71	nw.	6.7
June 20.											
1:08 p. m.	714.8	26.4	64	w.	2.7	526	714.8	26.4	64	w.	2.7
1:20 p. m.	714.7	26.6	66	w.	1.8	1665	627.1	17.1	......	w.	....
1:30 p. m.	714.7	26.9	64	w.	2.2	1229	659.6	19.5	......	w.	....
1:55 p. m.	714.6	27.2	68	w.	1.8	975	679.1	22.5	......	sw.	....
2:03 p. m.	714.6	27.9	61	w.	1.8	526	714.6	27.9	61	w.	1.8
June 21.											
2:11 p. m.	715.4	29.8	49	ese.	3.1	526	715.4	29.8	49	ese.	3.1
2:26 p. m.	715.4	29.2	54	se.	3.6	1527	638.5	19.6	......	se.	....
2:52 p. m.	715.4	28.6	51	s.	3.6	923	684.2	24.4	......	s.	....
3:02 p. m.	715.4	28.8	53	se.	4.0	526	715.4	28.8	53	se.	4.0

June 18.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 7500 m.; at maximum altitude, 7000 m.

At the beginning there were a few A.-St. and 5/10 St.-Cu. from the northwest, after 10:14 a. m., 5/10 A.-St. and 5/10 St.-Cu. Light rain fell from 10:26 to 10:40 a. m.

Pressure was high over Alabama and low over the New England States.

June 19.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 7500 m.; at maximum altitude, 6700 m.

There were 4/10 to 8/10 Ci.-St. from the west before 9:33 a. m. A few St.-Cu. at an altitude of 1200 m. formed at 9:31, increased to 9/10 by 10:19 and diminished to 5/10 by 11:37 a. m.

Pressure was low off the New England coast and high over the Gulf of Mexico.

June 20.—One balloon was used; capacity, 31.1 cu. m. Wire out, 1900 m.

There were a few St.-Cu. from the west.

Pressure was high over the Mississippi Valley and comparatively low over Maryland.

June 21.—One balloon was used; capacity, 31.1 cu. m. Wire out, 1500 m.

There were 7/10 A.-St. from the north.

A high was central over Lake Michigan, and a low over New Brunswick.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m. Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	At different heights above sea. Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910.											
June 22.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
10:45 a. m....	716.8	25.8	68	calm.	0.0	526	716.8	25.8	68	calm.	0.0
11:09 a. m....	716.8	27.1	65	ese.	2.7	1896	612.1	16.8	......	calm.	....
11:24 a. m....	716.8	27.5	60	ese.	2.7	1318	654.6	19.6	......	calm.	....
11:36 a. m....	716.8	27.6	60	se.	2.7	867	689.7	23.0	......	calm.	....
11:40 a. m....	716.8	27.7	59	ese.	2.7	526	716.8	27.7	59	ese.	2.7
June 23.											
2:37 p. m....	714.9	30.0	49	wsw.	2.7	526	714.9	30.0	49	wsw.	2.7
2:57 p. m....	714.8	30.4	49	w.	2.7	1674	627.8	21.0	......	nw.	....
3:23 p. m....	714.8	30.0	49	w.	2.2	1046	674.2	24.6	......	nw.	....
3:39 p. m....	714.8	30.6	47	w.	2.2	526	714.8	30.6	47	w.	2.2
June 24.											
10:16 a. m....	716.1	23.0	73	nw.	6.3	526	716.1	23.0	73	nw.	6.3
11:43 a. m....	716.1	23.5	60	nnw.	7.2	863	689.1	22.5	......	nw.	....
12:16 p. m....	716.2	23.9	62	nnw.	7.2	1300	655.2	18.9	......	nw.	....
12:28 p. m....	716.2	24.1	68	nnw.	6.7	1822	616.5	14.7	......	nw.	....
12:42 p. m....	716.2	23.9	61	nnw.	5.8	2348	579.2	11.4	......	nnw.	....
12:52 p. m....	716.3	23.6	64	nnw.	5.8	2858	545.0	8.7	......	nnw.	....
1:14 p. m....	716.3	23.0	67	nnw.	4.9	3422	508.5	4.1	......	nw.	....
1:35 p. m....	716.3	22.6	70	nnw.	4.5	2596	561.7	8.5	......	nw.	....
1:53 p. m....	716.3	22.0	73	nnw.	5.4	1762	620.2	13.4	......	nnw.	....
2:11 p. m....	716.3	23.4	62	nw.	4.5	1228	660.7	18.1	......	nnw.	....
2:22 p. m....	716.3	24.0	64	nw.	4.5	844	690.7	19.9	......	n.	....
2:27 p. m....	716.3	24.2	64	nw.	4.9	526	716.3	24.2	64	nw.	4.9
June 25.											
2:28 p. m....	720.4	22.2	54	sse.	4.5	526	720.4	22.2	54	sse.	4.5
2:35 p. m....	720.3	22.4	54	sse.	3.1	794	698.4	20.0	......	sse.	....
2:48 p. m....	720.3	22.8	55	sse.	3.6	1082	675.5	17.6	......	sse.	....
3:00 p. m....	720.2	21.8	56	sse.	4.0	751	701.8	19.5	......	sse.	....
3:08 p. m....	720.2	22.5	59	sse.	3.6	526	720.2	22.5	59	sse.	3.6
June 26.											
7:07 a. m....	721.2	16.4	85	s.	4.0	526	721.2	16.4	85	s.	4.0
7:46 a. m....	721.4	16.6	86	sse.	5.4	797	699.0	18.5	......	ssw.	....
8:38 a. m....	721.3	17.7	85	sse.	5.4	1161	669.7	15.2	......	ssw.	....
9:46 a. m....	721.0	19.2	80	sse.	8.0	1989	606.8	10.5	......	ssw.	....
10:24 a. m....	720.9	20.2	75	sse.	8.0	1462	646.0	13.7	......	ssw.	....
10:30 a. m....	720.9	20.3	70	sse.	8.0	1086	675.1	16.7	......	s.	....
10:41 a. m....	720.9	20.1	67	sse.	8.9	833	695.6	15.6	......	s.	....
10:50 a. m....	720.8	20.5	70	sse.	8.9	526	720.8	20.5	70	sse.	8.9

June 22.—One balloon was used; capacity, 31.1 cu. m. Wire out, 1500 m.

There were 7/10 Ci. from the west and a few Cu. from the southeast.

At 8 a. m. pressure was moderately low over the Gulf of St. Lawrence and relatively high over the Eastern States.

June 23.—One balloon was used; capacity, 31.1 cu. m. Wire out, 1440 m.

There were a few Cu. near the horizon.

Pressure was high over the Mississippi and Ohio valleys and low over Maine.

June 24.—Four kites were used; lifting surface, 31.1 sq. m. Wire out, 4000 m.; at maximum altitude, 3800 m.

Light haze throughout the flight. From 11:45 a. m. until the end, there were a few to 7/10 St.-Cu. from the northwest.

Low pressure was central off the New Jersey coast and high pressure over Ontario.

June 25.—One balloon was used; capacity, 31.1 cu. m. Wire out, 900 m.

There were 3/10 Cu. from the southwest.

Pressure was high over Ontario and relatively low over Georgia.

June 26.—Six kites were used; lifting surface, 43.2 sq. m. Wire out, 4700 m.; at maximum altitude, 3700 m.

At the beginning there were 2/10 St.-Cu. from the west. After 9:33 a. m. there were a few St.-Cu. from the south.

Pressure was high off the middle Atlantic coast and relatively low over the Mississippi Valley.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
June 27.	*mm.*	°*C.*	%		*m. p. s.*	*m.*	*mm.*	°*C.*	%		*m. p. s.*
4:50 p. m....	713.3	25.6	71	wnw.	4.9	526	713.3	25.6	71	wnw.	4.9
5:00 p. m....	713.2	25.8	68	wnw.	4.9	1583	631.5	18.1	......	wsw.	....
5:20 p. m....	713.3	25.4	70	wnw.	3.6	1086	669.1	20.4	......	sw.	....
5:33 p. m....	713.3	25.3	70	wnw.	2.7	780	693.0	22.8	......	sw.	....
5:42 p. m....	713.3	25.4	71	e.	2.7	526	713.3	25.4	71	e.	2.7
June 28.											
8:21 a. m....	712.6	18.6	96	wnw.	9.4	526	712.6	18.6	96	wnw.	9.4
8:27 a. m....	712.6	18.6	96	wnw.	9.8	898	682.3	15.8	......	wnw.	....
8:40 a. m....	712.6	18.7	96	wnw.	11.6	1332	648.4	14.0	......	nw.	....
9:14 a. m....	712.7	18.7	99	wnw.	6.7	1852	609.6	11.0	......	nw.	....
9:16 a. m....	712.7	18.8	99	wnw.	6.7	2149	588.4	11.9	......	nw.	....
9:20 a. m....	712.7	18.9	99	wnw.	5.8	2502	564.1	10.0	......	nw.	....
9:40 a. m....	712.7	19.0	98	nw.	5.8	526	712.7	19.0	98	nw.	5.8
June 29.											
8:18 a. m....	715.8	20.7	79	wnw.	10.3	526	715.8	20.7	79	wnw.	10.3
9:43 a. m....	715.8	22.4	70	wnw.	7.2	901	685.7	22.2	......	nw.	....
9:57 a. m....	715.8	22.8	68	wnw.	7.6	1190	663.2	19.6	......	nw.	....
10:27 a. m....	715.8	23.6	61	wnw.	6.3	1640	629.3	16.1	......	nw.	....
10:39 a. m....	715.7	23.6	56	nw.	8.9	1095	670.3	17.4	......	nw.	....
11:08 a. m....	715.7	24.0	56	nw.	6.3	856	689.1	20.1	......	nw.	....
11:12 a. m....	715.7	24.0	58	nw.	6.3	526	715.7	24.0	58	nw.	6.3
June 30.											
6:40 a. m....	716.4	21.0	70	nw.	8.9	526	716.4	21.0	70	nw.	8.9
6:45 a. m....	716.4	21.0	70	nw.	8.9	811	693.3	20.8	......	nw.	....
7:36 a. m....	716.5	20.9	74	nw.	7.6	1559	635.9	19.2	......	nnw.	....
8:01 a. m....	716.6	21.2	74	nw.	7.6	1990	604.6	16.2	......	n.	....
8:31 a. m....	716.7	21.7	76	nw.	5.4	2499	569.6	13.4	......	n.	....
8:53 a. m....	716.7	22.4	74	nw.	4.9	1885	612.5	17.2	......	n.	....
9:03 a. m....	716.7	22.6	72	nw.	4.9	1030	676.4	20.8	......	s-	
9:12 a. m....	716.7	22.8	73	nw.	4.9	526	716.7	22.8	73	nw.	4.9

June 27.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2000 m.

About 6/10 A.-Cu. and 2/10 Cu.-Nb. from the west-northwest prevailed. There was a thunderstorm in the east-southeast.

At 8 a. m. pressure was relatively high off the South Atlantic States and low over the Gulf of St. Lawrence and the lower Mississippi Valley.

June 28.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 3200 m., at maximum altitude.

There were 2/10 A.-St. and from 8/10 to 3/10 St.-Cu. both from the northwest until 8:49 a. m. St. from the west-northwest appeared at 8:49 and covered the sky after 8:56 a. m. Light rain fell from 8:35 to 8:49. a. m. There was light fog from 9:06 to 9:20 a. m. All kites were in the clouds after 8:49 a. m.

Pressure was high over Michigan and low over New Brunswick.

June 29.—Seven kites were used; lifting surface, 45.1 sq. m. Wire out, 5300 m.; at maximum altitude, 1800 m.

There were 3/10 to 2/10 A.-St. from the northwest during the flight.

High pressure, central over Wisconsin, extended over most of the United States east of the Rocky Mountains. A low was central over New Brunswick.

June 30.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 4150 m.; at maximum altitude, 3400 m.

There were 2/10 Ci.-St. from the northwest.

High pressure was central over eastern Iowa. Centers of low pressure were over New Brunswick and northwestern Florida.

Surface temperatures.

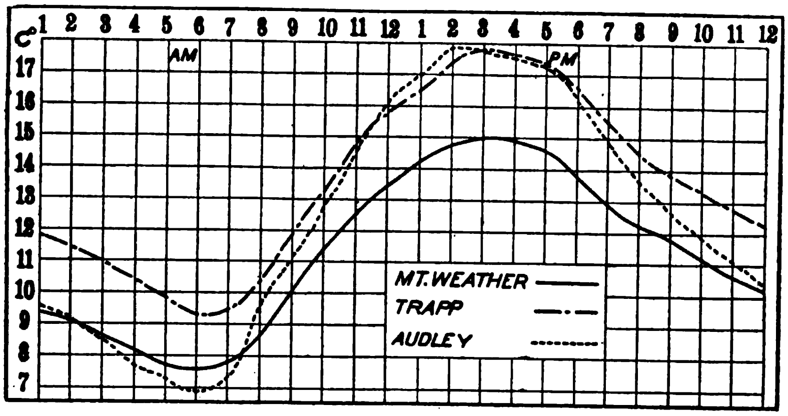


FIG. 4.—Mean hourly temperatures, April, 1910.

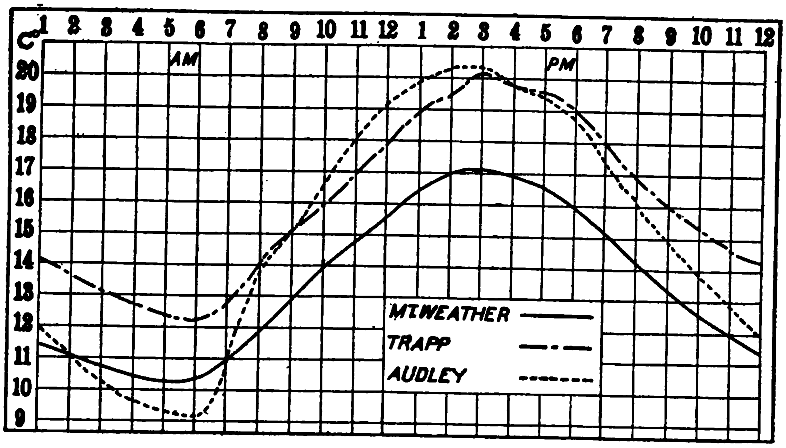


FIG. 5.—Mean hourly temperatures, May, 1910.

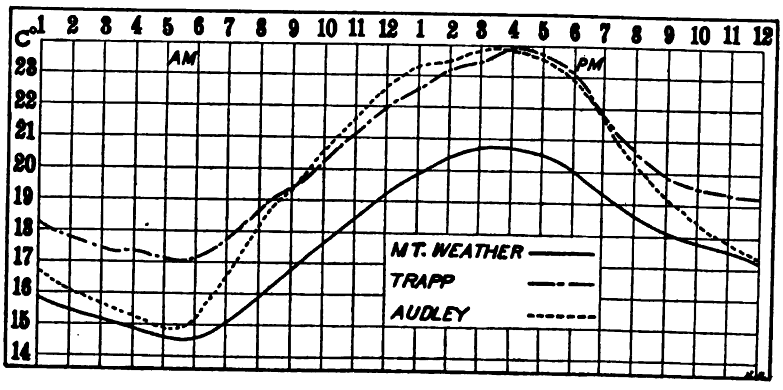
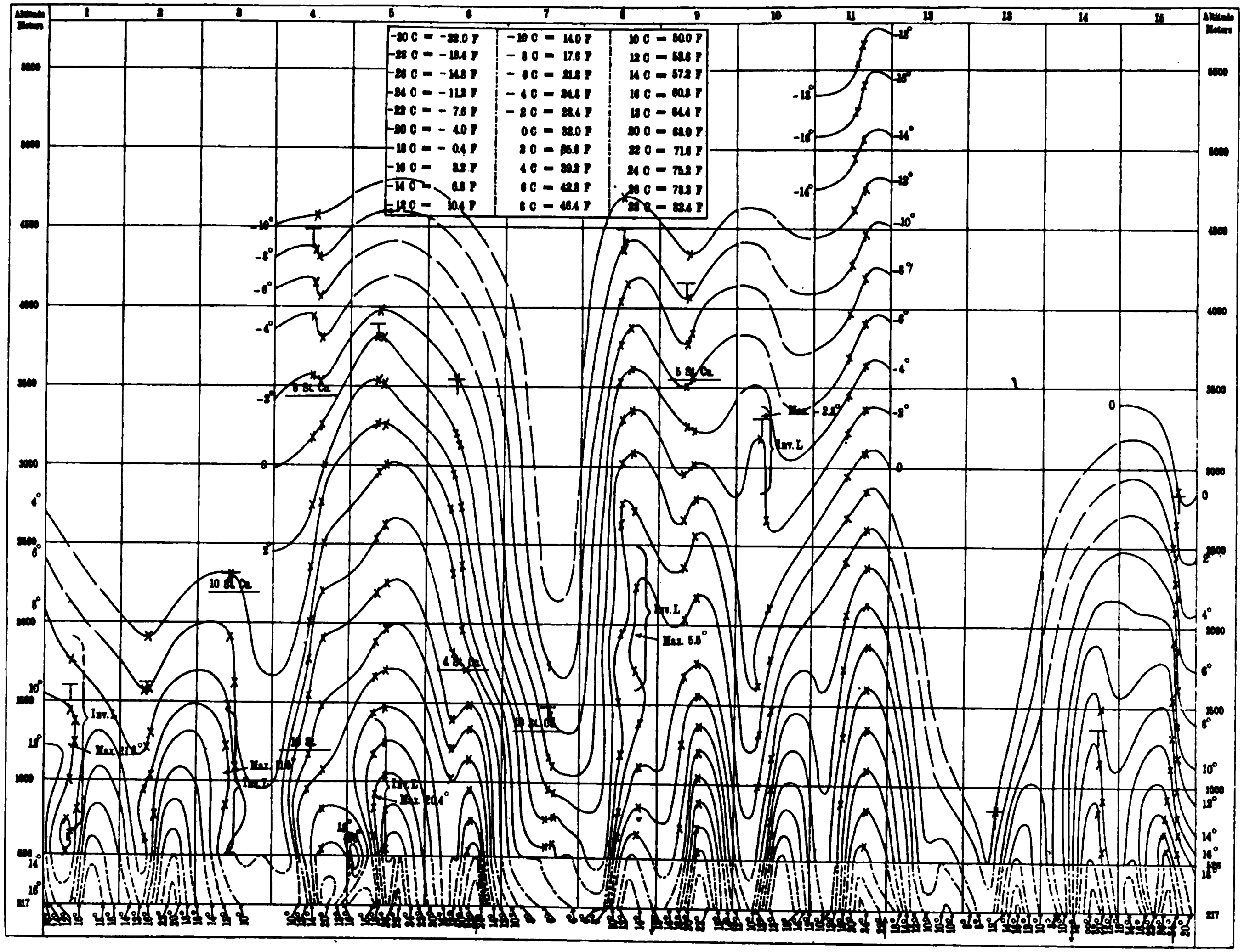
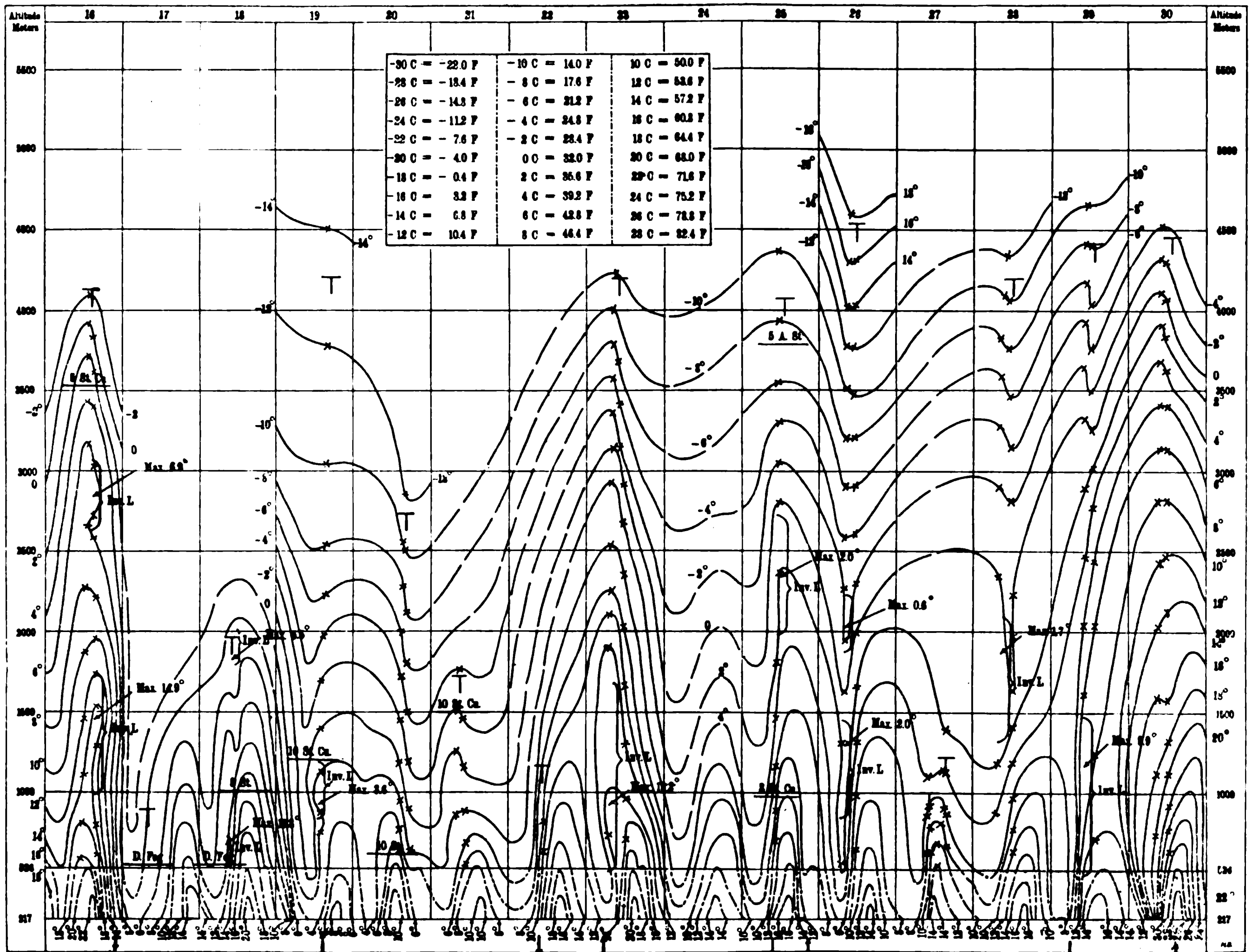


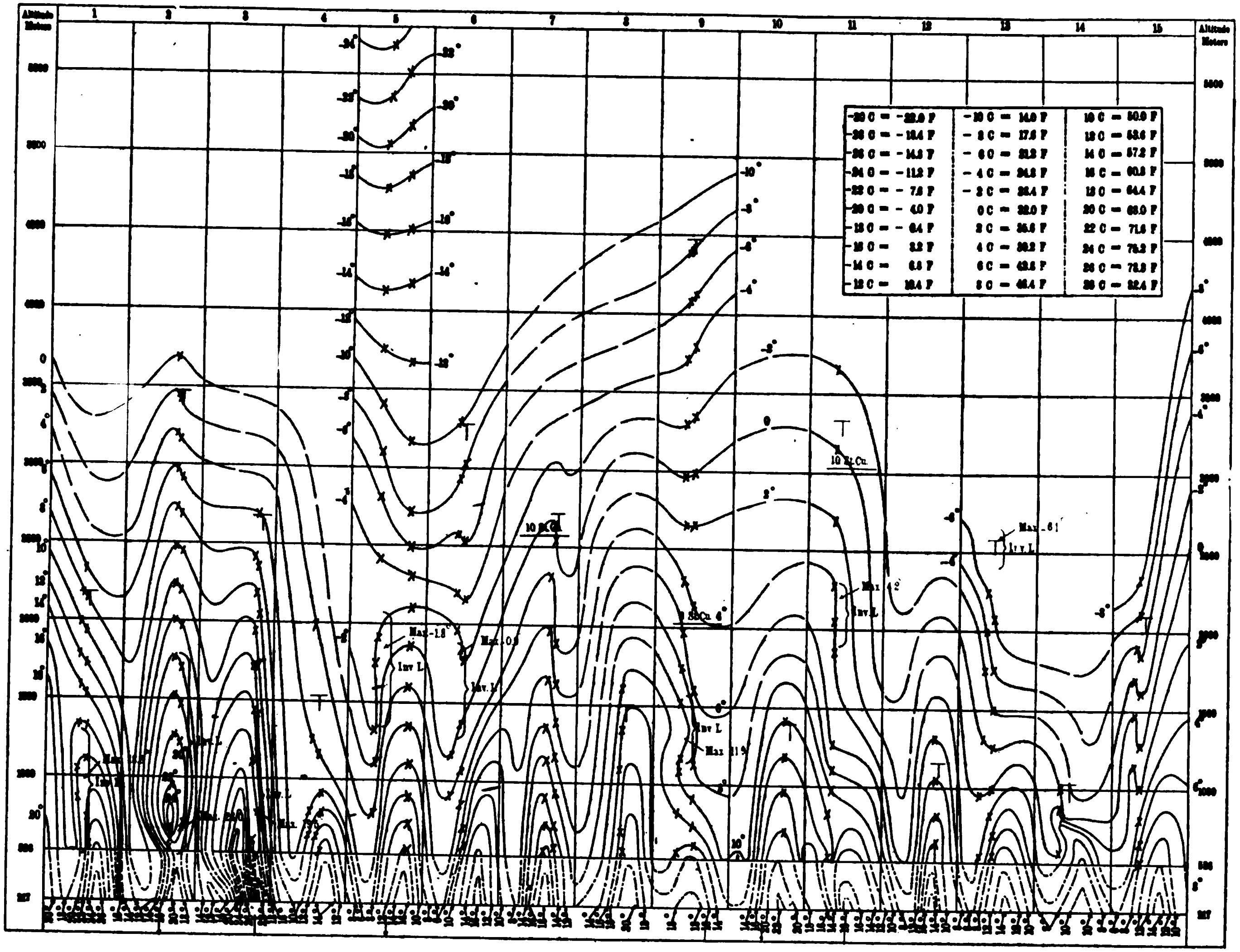
FIG. 6.—Mean hourly temperatures, June, 1910.



Free air isotherms, April 1-15, 1910.

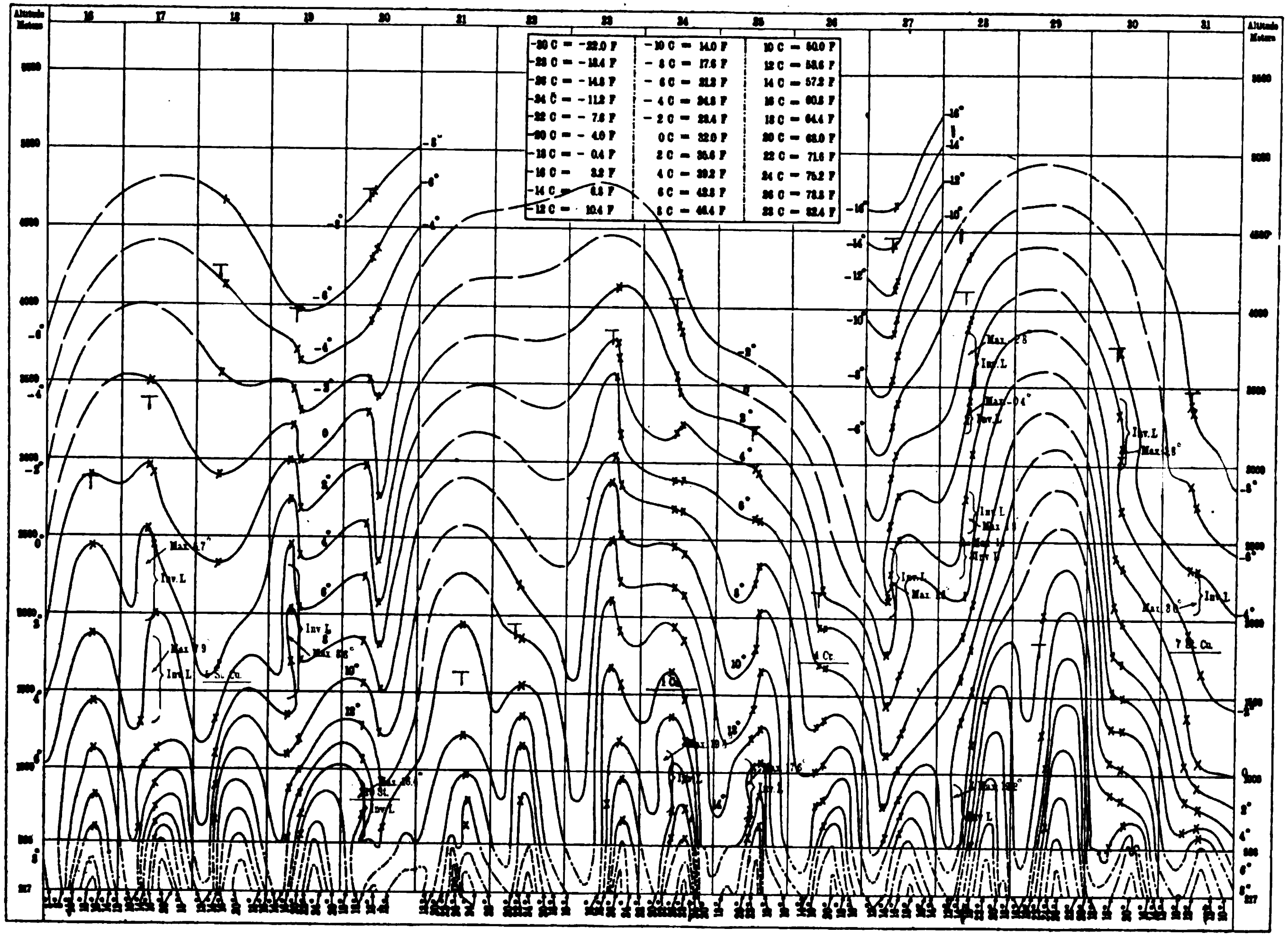


Free air isotherms, April 16–30, 1910.

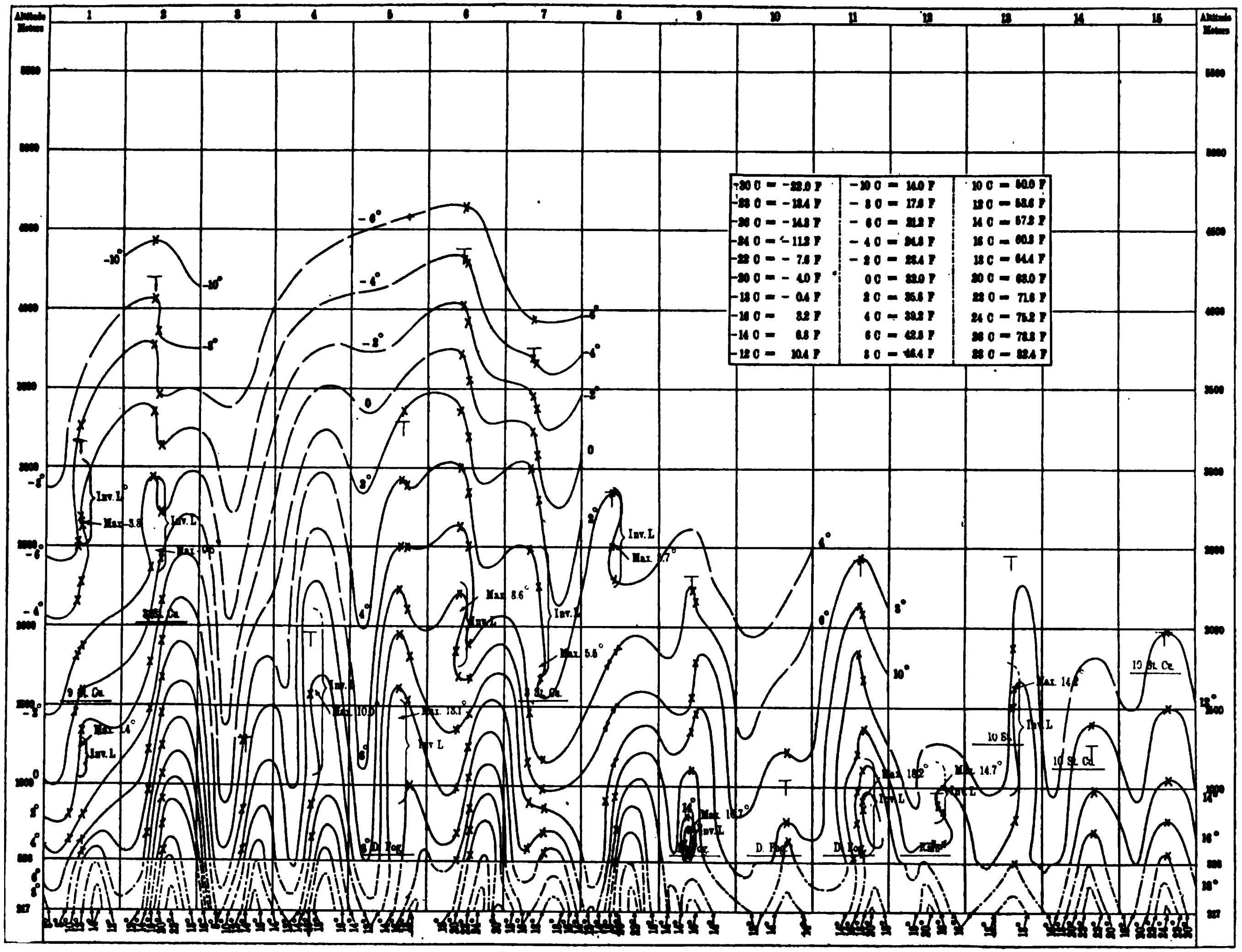


Free air isotherms, May 1–15, 1910.

Chart X.

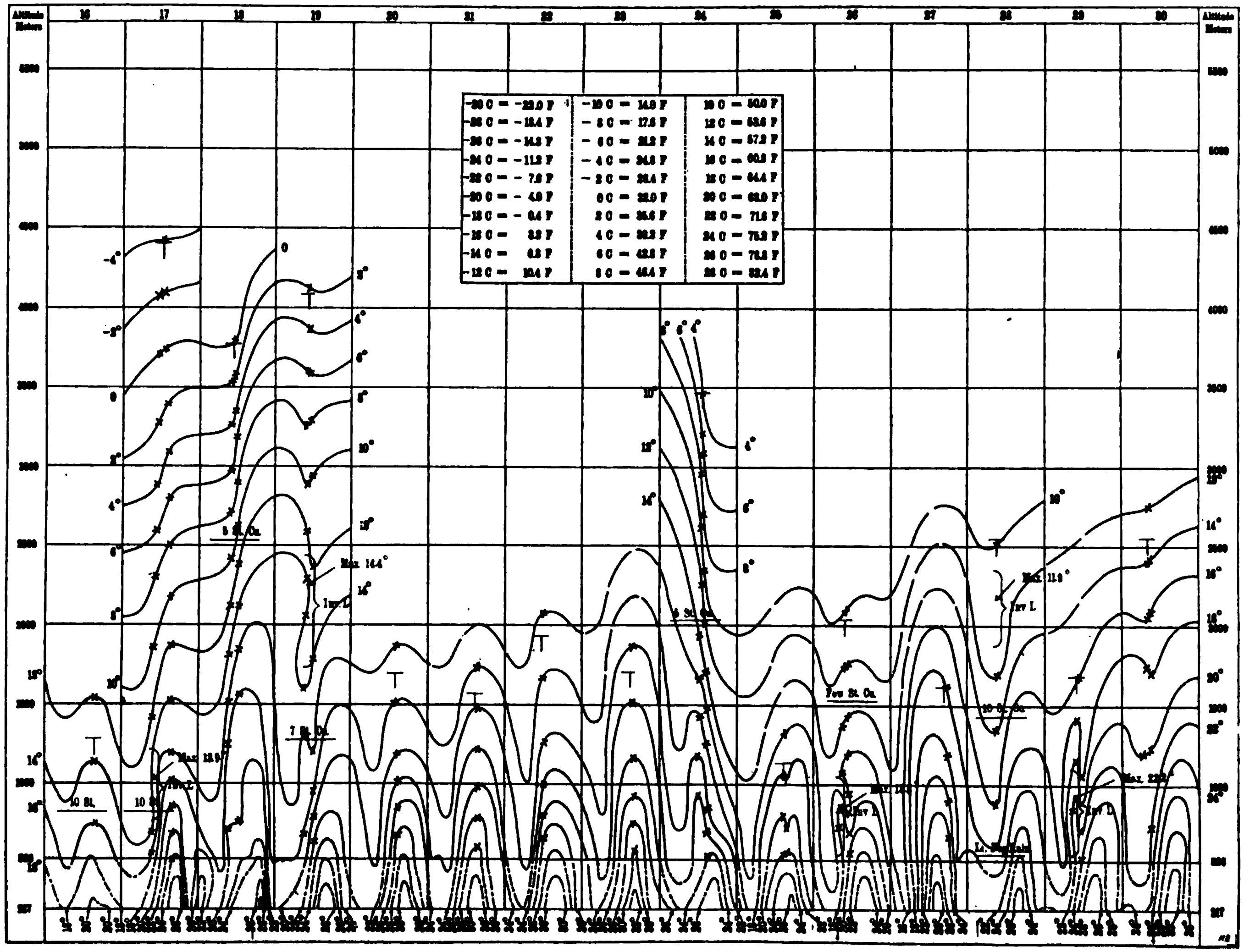


Free air isotherms, May 16–31, 1910.



-30 C = -22.0 F	-10 C = 14.0 F	10 C = 50.0 F
-28 C = -18.4 F	- 8 C = 17.6 F	12 C = 53.6 F
-26 C = -14.8 F	- 6 C = 21.2 F	14 C = 57.2 F
-24 C = -11.2 F	- 4 C = 24.8 F	16 C = 60.8 F
-22 C = - 7.6 F	- 2 C = 28.4 F	18 C = 64.4 F
-20 C = - 4.0 F	0 C = 32.0 F	20 C = 68.0 F
-18 C = - 0.4 F	2 C = 35.6 F	22 C = 71.6 F
-16 C = 3.2 F	4 C = 39.2 F	24 C = 75.2 F
-14 C = 6.8 F	6 C = 42.8 F	26 C = 78.8 F
-12 C = 10.4 F	8 C = 46.4 F	28 C = 82.4 F

Free air isotherms, June 1-15, 1910.



Free air isotherms, June 16–30, 1910.

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U. S. DEPARTMENT OF AGRICULTURE

[illegible] **BULLETIN** [illegible]

OF THE

MOUNT WEATHER OBSERVATORY

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WASHINGTON

U. S. WEATHER BUREAU

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BULLETIN

OF THE

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(IX) VARIATIONS OF TEMPERATURE AND PRESSURE AT SUMMIT AND BASE STATIONS IN THE ROCKY MOUNTAIN REGION.

By ALFRED J. HENRY. (Dated September 29, 1910.)

The changes in the atmosphere in a vertical direction are best determined by kite and balloon ascensions. These, however, are not available in extraordinary weather conditions and in fair weather they give a record for the time of the ascensions only. When two points are situated near to each other, the one on a mountain, the other in a valley below, they may be considered as approximating somewhat closely to points in the free air and although the absolute data, particularly as to temperature, are affected by the mountain mass, yet the changes with time should closely approximate those in the free air. It is the purpose of this paper to examine the simultaneous records of temperature and pressure at summit and base stations in the Rocky Mountain region with a view of increasing our knowledge as to the character of the changes in these elements which actually take place under varying weather conditions.

There are available for this purpose simultaneous records of temperature at Corona, Colo., altitude 3554 meters (11660 feet), and at Denver, Colo., altitude 1630 meters (5347 feet), distant in an air line about 61 kilometers (38 miles), The difference in altitude between Corona and Denver is 1925 meters (6313 feet). We also have simultaneous records of temperature, pressure, wind direction, and velocity at Pikes Peak and Colorado Springs, Colo. The altitude of the former is 4301 meters (14111 feet) and of the latter, 1858 meters (6098 feet). The horizontal distance between the two stations is about 19 kilometers (12 miles) in an air line, Colorado Springs being nearly due east of Pikes Peak.

The instrumental equipment of Corona consists of a Richard thermograph, a Robinson anemometer Weather Bureau type, a self-registering device for velocity only, and a set of standard thermometers, including self-registering maximum and minimum. One observation is made daily at Corona and the results are telegraphed to Denver, Colo. The last-named station is the headquarters of District Forecaster Brandenburg, and the observations at Corona are made primarily for his use in making forecasts and warnings for the Central Rocky Mountain District. The continuous temperature record for the Denver station is also made by a Richard thermograph whose traces are controlled by observations of standard thermometers twice daily. The observations at Pikes Peak and Colorado Springs, Colo., were made by trained observers of the Weather Bureau in 1892, 1893, and 1894. The continuous automatic records of temperature and pressure at both these stations were checked by eye readings made three times daily. The tabular results of the observations for Pikes Peak and Colorado Springs were published *in extenso* in the quarto annual reports of the Chief of the Weather Bureau for 1893 and 1894.

The geographic position of Pikes Peak and Colorado Springs is well known. Corona is on the Denver, Northwestern and Pacific Railway, at the point where the latter crosses the Continental Divide, about 61 kilometers (38 miles) west-northwest of Denver. This station was established in 1908 by District Forecaster F. H. Brandenburg. For substantial aid in its establishment and maintenance the Weather Service is greatly indebted to the officials of the railroad above named.

The station at Corona is in what is sometimes known as Rollins Pass, at an altitude of 3554 meters (11660 feet). The ridge known as the Divide immediately to the south of Corona rises to an altitude of about 3940 meters (12000 feet). To the north of the pass isolated peaks rise still higher. To the westward the descent into Middle Park is quite rapid; the altitude drops to 2609 meters (6560 feet) in a distance from Corona of 12 kilometers (7½ miles). The general altitude of the floor of the Park is not far from 2100 meters (6890 feet). The mountains which form the Continental Divide at Corona are known as the Front Range. Their general trend is north and south, but at a short distance north of Corona they change their direction very abruptly to east and west and pass westward, forming the northern boundary of Middle Park. They also serve as a protection to the Park against northerly winds, but they do not obstruct the western horizon from Corona. The winds at the latter station are almost uniformly from the west and to a certain extent they must be ascending winds, since they rise from the floor of the Park about 1454

meters (4770 feet) below.[1] Eastward from Corona the mountains and foothills drop to the level of the plains within a distance of about 32–40 kilometers (20–25 miles). Denver, the base station, is situated on these plains about 21 kilometers (13 miles) east of the nearest foothills. Since the station at Corona is not equipped with a barograph our first remarks will refer only to temperature as recorded at that station and Denver during the interval, November, 1909, to March, 1910, both inclusive; later the simultaneous temperature and pressure records of Pikes Peak and Colorado Springs, Colo., will be briefly discussed.

To readily compare the temperature fluctuations at upper and lower stations, it is first convenient to plat the course of the temperatures on cross-section paper. This has been done for Corona and Denver for two-hour intervals, the temperatures for the even hours being used. Thus the plat shows the temperatures at each station for midnight, 2 a. m., 4 a. m., 6 a. m., etc., throughout the day. The temperatures thus platted for each station are connected by respective free hand curves, which latter thus show the course of the temperature throughout the day, and from one day to another.

In general the courses of the temperatures at the two stations, Corona and Denver, run parallel, that is, the various fluctuations occur rather close together in point of time and are similarly directed. But under the various weather conditions which arise, especially in the cold season, the curves may not run parallel and their courses may be oppositely directed; thus the temperature may be falling at one station while it is rising at the other. Likewise for very short intervals the temperature at the upper station, which in the natural order of things should be the lowest, becomes the highest.

The differences in temperature between an upper and a lower station may be conveniently discussed by means of the vertical temperature gradient, that is, the amount by which the temperature decreases for each unit of increase in altitude. The gradient is expressed most conveniently in centigrade degrees for units of 100 meters (328 feet). When a mass of dry air ascends without the passage of heat to or from the surrounding atmosphere it cools adiabatically at the rate of 1° C. for every 100 meters of ascent, or 1.6° F. for every 300 feet. Thus if a mass of dry air on the level of Denver were to rise to the level of Corona, a distance of 1924 meters (6310 feet), it would thereby cool adiabatically 19.24° C. (34.5° F.). In natural moist air the adiabatic rate varies from zero up to 1° C., and the average rate observed between mountain and low-lying adjacent stations is not far from 0.5° C., or about half the adiabatic rate for dry

[1] Later information shows that these winds do not ascend from the floor of the Park.

air, so that instead of 19.24° C. we may expect a cooling of about 10° C.

In Table 1 are given for 7 a. m. the observed vertical temperature gradients between Denver and Corona in the column marked C. at the top, and between Denver and Leadville in the column marked L. at the top, for each day from November 1, 1909, to March 31, 1910. The gradient between Denver and Leadville has been added to show in what degree the temperature changes over the eastern Rocky Mountain slope in Colorado are simultaneous.

TABLE 1.—*Vertical temperature gradients at 7 a. m. (eastern time) in degrees centigrade per 100 meters between the two Rocky Mountain stations—Corona, Colo. (3554 meters), and Leadville, Colo. (3125 meters)—and Denver, Colo (1630 meters), the latter being used as a base station.*

Date.	1909.				1910.					
	November.		December.		January.		February.		March.	
	C.	L.	C.	L.	C.	L.	C.	L.	C.	L.
1	0.73	0.60	0.73	0.71	0.70	0.75	0.58	0.78	0.73	0.63
2	0.64	0.60	0.44	0.37	−0.12	−0.48	0.61	0.19	0.93	1.23
3	0.41	0.37	0.76	0.37	−0.03	−0.04	0.35	0.30	0.49	0.56
4	0.38	0.30	0.35	0.30	0.29	0.41	0.35	0.71	0.55	0.63
5	0.29	0.41	0.44	−0.22	0.55	0.56	0.29	0.63	0.44	0.37
6	0.62	0.26	0.32	0.19	0.64	0.67	0.46	0.45	0.44	0.26
7	0.64	0.56	0.06	−0.48	0.96	0.26	0.46	0.45	0.23	0.04
8	0.15	0.30	−0.03	0.00	0.73	1.04	0.52	0.37	0.61	0.41
9	0.29	0.60	0.17	−0.19	0.00	0.04	0.32	0.26	0.70	0.60
10	0.87	0.41	−0.06	−0.34	0.32	0.11	0.61	0.75	0.64	0.71
11	0.58	0.45	0.87	0.90	0.00	0.00	0.76	0.82	0.29	0.45
12	0.64	0.48	0.73	0.41	0.33	0.41	0.61	0.45	0.55	0.52
13	0.49	0.22	0.93	0.93	0.64	0.75	0.44	0.07	0.58	0.56
14	0.46	0.71	0.64	0.52	0.12	−0.04	0.55	0.48	0.32	0.41
15	0.03	0.04	0.64	0.71	0.55	0.56	1.04	0.93	0.29	0.30
16	0.76	0.71	0.76	0.48	0.78	0.97	0.67	0.45	0.38	0.48
17	0.20	0.07	0.76	0.78	0.78	0.52	0.87	0.71	0.61	0.48
18	0.46	0.52	0.35	0.22	1.27	1.42	0.67	0.41	0.46	0.22
19	0.64	0.75	0.38	0.56	0.52	0.63	0.38	0.11	0.38	0.19
20	0.70	0.63	0.32	0.45	0.58	0.37	0.41	0.26	0.49	0.22
21	0.23	0.04	0.26	0.37	0.49	0.60	0.52	0.30	0.49	0.30
22	0.44	0.22	−0.12	−0.11	0.96	1.12	−0.03	−0.41	0.55	0.52
23	0.90	0.86	−0.03	−0.07	0.44	0.63	0.15	−0.19	0.87	0.78
24	0.76	0.75	0.70	0.60	0.58	0.37	0.55	0.26	0.44	0.15
25	0.23	0.41	0.46	0.41	0.87	0.67	0.34	0.56	0.52	0.22
26	0.76	0.86	0.93	0.67	1.16	1.12	1.02	0.93	0.52	0.41
27	0.87	1.00	0.52	0.30	1.14	1.19	0.64	0.45	0.67	0.30
28	0.06	0.45	0.52	0.41	1.02	1.30	0.90	0.90	0.76	0.48
29	0.38	0.30	0.15	0.22	0.76	0.75	....	....	0.70	0.63
30	0.23	0.48	0.67	0.71	0.90	0.93	....	....	0.52	0.07
31	....	....	0.41	0.34	0.61	0.63	....	....	0.32	0.41
Means	0.48	0.48	0.45	0.34	0.60	0.59	0.55	0.44	0.53	0.44
Correc'd means	0.80	....	0.56	....	0.74	....	0.69	....	0.68	....

The station at Leadville is distant from Denver about 130 kilometers (81 miles) in a southwesterly direction. It lies directly east of the range of mountains whose summits slightly exceed 4200 meters (13780 feet) and is therefore more or less sheltered from west winds; its alti tude is 3125 meters. The gradients given without algebraic sign indicate a *decrease* in temperature with altitude; those with a negative sign

prefaced indicate that the temperature was *higher* at the upper than at the lower station. Considering the gradients as a whole they show, as might be expected, that the lower layers of the atmosphere as regards temperature are in a condition of continual change from day to day. The individual morning gradients for single days, while differing largely from each other, are pretty nearly the same for the mean of each month, although it appears that in some months the 7 a. m. gradient between Denver and Leadville is smaller than that between Denver and Corona.

TABLE 2.—*Vertical temperature gradient for every hour in degrees centigrade per 100 meters between Pikes Peak, Colo. (4301 meters), and Colorado Springs, Colo (1858 meters).*

Hours.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual means.
1 a. m.	0.53	0.47	0.60	0.63	0.60	0.61	0.58	0.53	0.51	0.48	0.48	0.48	0.54
2 a. m.	0.52	0.46	0.57	0.61	0.59	0.58	0.56	0.52	0.50	0.47	0.48	0.47	0.53
3 a. m.	0.52	0.47	0.57	0.59	0.57	0.58	0.53	0.51	0.50	0.47	0.48	0.47	0.52
4 a. m.	0.51	0.47	0.54	0.58	0.56	0.54	0.52	0.49	0.47	0.46	0.48	0.47	0.51
5 a. m.	0.50	0.45	0.52	0.56	0.56	0.53	0.51	0.49	0.45	0.44	0.48	0.48	0.50
6 a. m.	0.51	0.44	0.52	0.59	0.60	0.58	0.54	0.51	0.45	0.44	0.49	0.48	0.51
7 a. m.	0.49	0.43	0.53	0.65	0.68	0.67	0.60	0.57	0.54	0.47	0.49	0.47	0.55
8 a. m.	0.51	0.50	0.61	0.73	0.73	0.75	0.68	0.66	0.66	0.58	0.57	0.50	0.62
9 a. m.	0.62	0.57	0.69	0.76	0.76	0.79	0.72	0.73	0.74	0.68	0.64	0.58	0.69
10 a. m.	0.71	0.66	0.74	0.79	0.78	0.81	0.75	0.75	0.76	0.75	0.73	0.66	0.74
11 a. m.	0.76	0.66	0.73	0.81	0.80	0.84	0.79	0.76	0.78	0.78	0.78	0.72	0.77
Noon	0.79	0.73	0.79	0.82	0.81	0.84	0.80	0.78	0.78	0.79	0.80	0.74	0.79
1 p. m.	0.80	0.69	0.81	0.84	0.82	0.86	0.81	0.78	0.77	0.81	0.80	0.74	0.79
2 p. m.	0.82	0.72	0.82	0.85	0.83	0.87	0.79	0.80	0.78	0.82	0.81	0.77	0.81
3 p. m.	0.82	0.71	0.82	0.86	0.82	0.87	0.80	0.82	0.79	0.82	0.81	0.73	0.81
4 p. m.	0.81	0.72	0.83	0.86	0.83	0.88	0.79	0.80	0.79	0.83	0.76	0.70	0.80
5 p. m.	0.74	0.70	0.83	0.86	0.83	0.88	0.79	0.76	0.78	0.80	0.68	0.69	0.78
6 p. m.	0.68	0.65	0.80	0.85	0.82	0.86	0.77	0.75	0.74	0.72	0.67	0.60	0.74
7 p. m.	0.63	0.60	0.75	0.82	0.79	0.82	0.75	0.71	0.70	0.67	0.57	0.56	0.70
8 p. m.	0.61	0.56	0.73	0.78	0.76	0.78	0.72	0.66	0.65	0.62	0.54	0.52	0.66
9 p. m.	0.59	0.54	0.68	0.75	0.72	0.74	0.68	0.64	0.61	0.58	0.52	0.52	0.63
10 p. m.	0.56	0.50	0.65	0.71	0.69	0.69	0.65	0.61	0.57	0.55	0.52	0.50	0.60
11 p. m.	0.54	0.48	0.60	0.68	0.66	0.66	0.63	0.58	0.55	0.51	0.50	0.48	0.57
Midnight	0.53	0.47	0.61	0.66	0.63	0.62	0.60	0.58	0.54	0.48	0.49	0.48	0.56
Hourly means.	0.63	0.57	0.68	0.74	0.72	0.74	0.68	0.66	0.64	0.63	0.61	0.58	0.66

If, instead of determining the vertical temperature gradient for any one hour of the day, the mean gradients be determined for every hour of the day, as has been done for the air column between Pikes Peak and Colorado Springs, Colo. (see the figures in Table 2), it will be found that the gradient varies from hour to hour as well as from day to day, being smallest in the night hours and greatest in the hours of daylight. Between Pikes Peak and Colorado Springs the gradient is least about 5 o'clock in the morning and greatest at the hours of 2 and 3 o'clock in the afternoon. In considering the absolute values of temperature gradients, therefore, it is essential to know the hours at which the temperatures were observed, and for which the gradients were computed. The daily range of temperature, or the rise from early morning to the middle of the afternoon, at Colorado Springs is on the average more than double that

of Pikes Peak. As a consequence the temperatures at the two stations draw further apart as the day advances and the average gradient is a maximum about the time of maximum temperature at the lower station.

Departures from the normal gradients of fair weather are caused by moving cyclones and anticyclones which pass across the mountains from west to east, or southeastward over the plains without actually crossing the mountains. The changes in temperature produced by these moving masses of air form, perhaps, the most important phase of the weather which prevails in the Rocky Mountain region.

A clear understanding of the circulation of the air around cyclones and anticyclones will enable one to more clearly comprehend some of the temperature changes that occur in the Rocky Mountain region and this is my excuse for restating certain fundamental facts as follows:

1. In a cyclone the surface winds blow spirally inward around the center of low barometric pressure in a direction the reverse of that of the movement of the hands of a clock.

2. In an anticyclone the movement of the surface winds is directly the opposite of that of a cyclone; instead of blowing spirally inward the direction of motion is outward from the center and the direction of rotation is clockwise instead of counter clockwise.

3. As a general proposition the surface air in the southeast quadrant of a cyclone is warm; that in the southeast quadrant of an anticyclone is cold.

4. In the cold season the weather in the Rocky Mountain region is conditioned largely by the eastward movement in latitude of cyclones and anticyclones. As is well known these follow certain established paths, in the order of frequency, as follows: First, along the northern boundary of the United States from British Columbia to the Lake region; second, from British Columbia southeastward over southern Idaho and northern Utah, crossing the Rocky Mountains in Wyoming and Colorado; a third and much less frequent path is eastward from southern California, through Arizona and New Mexico, passing to the Plains region south of Colorado.

5. With the eastward movement of a cyclone in any one of these three paths there usually follows in its rear an anticyclone or area of high pressure.

6. Whether any given cyclone will follow the first or the second of the paths above described appears to be conditioned on the path of the preceding cyclone and the pressure distribution on either side of the cyclone's path. Thus, cyclones follow the first path above described,

when pressure is already high in the Great Basin,[2] or on the right-hand side of the path as one faces the direction of movement; they follow the second when pressure is high over Alberta, or on the left-hand side of the path. With high pressure over the Great Basin and cyclones following path No. 1, the weather in the middle Rocky Mountain region is fair and the temperatures are relatively high. When cyclones follow path No. 2, precipitation, mostly in the form of snow, occurs and the temperatures are relatively low. Severe winter weather is occasioned in Colorado when areas of low pressure drift over the State from the west, as in path No. 3, followed by strong areas of high pressure which move south-southeastward from the northern interior. The areas of low pressure that visit Colorado come mostly from the North Pacific along path No. 2; they first appear on the coasts of Washington and Oregon and slowly advance southeastward over the northern portions of Nevada, Utah, southern Idaho, and Wyoming. The gyratory motion of their surface winds is largely absent, probably due to the mountainous character of the land over which they pass. A characteristic feature is a lack of symmetry in the wind circulation. Circular isobars are nearly always absent and the form of the depression is generally that of a long trough or lane of low pressure extending from the north Pacific coast southeastward to the middle Rocky Mountain region, in which two or three faintly defined centers of cyclonic circulation may appear. As soon as the trough crosses the main divide of the Rocky Mountains the eastern end of the disturbance assumes definite shape, the true surface cyclonic movement of the wind appears, and the cyclone moves off in its course toward the Gulf of Mexico or the Atlantic Ocean, as the case may be. The cyclone appears to be pinched off, so to speak, from the parent disturbance. Always associated with the above described condition is a great area of high pressure that overlies the region north of Montana. These great highs are centers of extremely low surface temperatures. This extensive mass of cold air in the interior of the continent is doubtless prevented at times from flowing to the southeast, and from crossing the low mountain passes of Montana and Idaho into the Great Basin, partly by the mountains themselves and partly by the pressure in and to the southwest of the narrow band or lane of low pressure and relatively high temperature hereinbefore described.

[2]Some extend the term "Plateau of the Great Basin" so as to include the whole elevated region between the Sierra Nevada on the west and the Wahsatch on the east. We may consider the term Great Basin to include the greater part of southern Idaho and western half of Utah, with portions of the States bordering these on the north and south.

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U. S. DEPARTMENT OF AGRICULTURE

BULLETIN

OF THE

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PREPARED UNDER THE DIRECTION OF
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WASHINGTON
U. S. WEATHER BUREAU

7. It has been elsewhere observed in the United States that a mass of cold air, with steep horizontal temperature gradients, does not always quickly underrun the warm air of a barometric trough unless the pressure on the opposite side of the trough gives way. In the northwestern part of the United States the barometric troughs or lanes of low pressure often persist for several days with as many as three or four centers of depression scattered around the periphery of the inland anticyclone. Each center of depression or cyclone is not followed at once by a corresponding anticyclone as is generally the case elsewhere in the United States. Suddenly, however, the trough of low pressure is obliterated and in due season the path hitherto occupied by cyclones is occupied by an anticyclone. It is probable that the statical pressure of the oceanic high over California and to the southwest over the Pacific Ocean is sufficient to prevent the cold air of the interior from overrunning the Great Basin. When the pressure in the southwest is diminished, however, as when an area of low pressure passes from southern California eastward over Arizona and New Mexico, then the cold air of the interior flows southward over the Rocky Mountain barrier and into the lowlands of Utah, Nevada, Arizona, and New Mexico. The general underlying principle seems to be that the pressure of the air over a region must diminish before the surface air can become decidedly colder.

Returning now to a consideration of the temperature changes in the air at base and summit stations we notice first that the character of the temperature curves above and below is quite different. The large diurnal change at the lower station becomes very much reduced at the upper station and is frequently absent, as may be seen by an inspection of the temperature curves in figs. 1 to 5, inclusive. This is particularly true during *periods of rising temperature.* The rise in temperature at the summit stations which begins with the increased insolation in the forenoon continues steadily during the late afternoon and night hours when after withdrawal of the solar heat the terrestrial radiation becomes so effective in cooling the atmosphere at lower levels.

Inversions in the air temperature between Corona and Denver and also between Pikes Peak and Colorado Springs occur rather infrequently. In the three months, December, 1909, January and February, 1910, there were only nine days when the temperature at Corona was higher than that at Denver. And during the three winter months of 1893-4 there were but six days when the temperature at Pikes Peak was higher than that at Colorado Springs, 2454 meters below. The main cause of these inversions is to be found in the movement of cyclones and anticyclones. When the latter move southeastwardly along the eastern

slope of the Rocky Mountains they are attended by a mass of air having temperatures 12° to 20° C. (22° to 36° F.) lower than the air directly in their course. This cold air flows along the surface and evidently underruns the warmer air since the temperatures at Pikes Peak may be either stationary or rising at the time the wall of cold air passes Colorado Springs on its way to lower latitudes. A graphical representation of this phenomenon, viz, an inversion of temperature between Pikes Peak and Colorado Springs, is shown in the lower part of fig. 1, also in fig. 2. The full line shows the temperature as automatically registered for each two hours on the summit of Pikes Peak and the broken line shows the temperatures at Colorado Springs for the corresponding hours. The broken lines in all of the figures which follow correspond to the lower station, the full lines to the upper station. The upper part of the figure shows the synchronous changes in pressure which occurred during each two hours of the twenty-four, viz, from midnight to 2 a. m., from 2 a. m. to 4 a. m., etc. The pressure changes are given in hundredths of an inch beginning at midnight of the day previous. They are calculated for intervals of two hours. The actual consecutive two-hourly temperatures (in degrees Fahrenheit) are given in the lower part of the figure. All of the plotted values were obtained from the records of self-recording instruments controlled by eye observations made three times each day. There is of course some small uncertainty in the pressure values at the upper station on account of the pumping of the barometer during high winds. So also the diurnal variation, especially in temperature, adds to the perplexity of interpreting the records. No correction has been made on account of diurnal variation since it was found that the probable errors made by attempting to eliminate it seemed to be of equal magnitude with those it was desired to remove.

Fig. 2 represents the course of the temperature and pressure at the summit of Pikes Peak and on the plains at Colorado Springs, 12 miles due east in an air line, during severe weather conditions in winter, when the curve of rising temperature on the mountain intersected and passed above the falling temperature of the plains station.

Reference to the daily weather map shows that these two cases of inversion occurred under weather conditions that were alike only in the broader features of the pressure distribution at the beginning of the periods. The pressure distributions at the close of the periods differed in that the center of the anticyclone on February 22 overlaid western Montana while that of February 11 overlaid the region north of the Dakotas. In the first case the course of the temperature at the upper

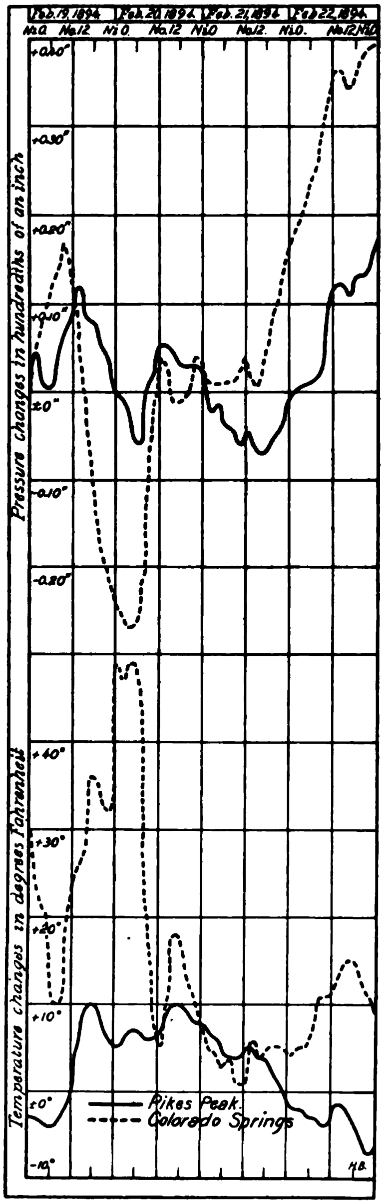

FIG. 1.—Synchronous changes in temperature and pressure at Pikes Peak and Colorado Springs during the advance of a cold wave southeastward over the plains. The letters "No. 12" and "NiO" at the head of the columns indicate 12 noon and 12 midnight, respectively, of the dates to which they appertain.

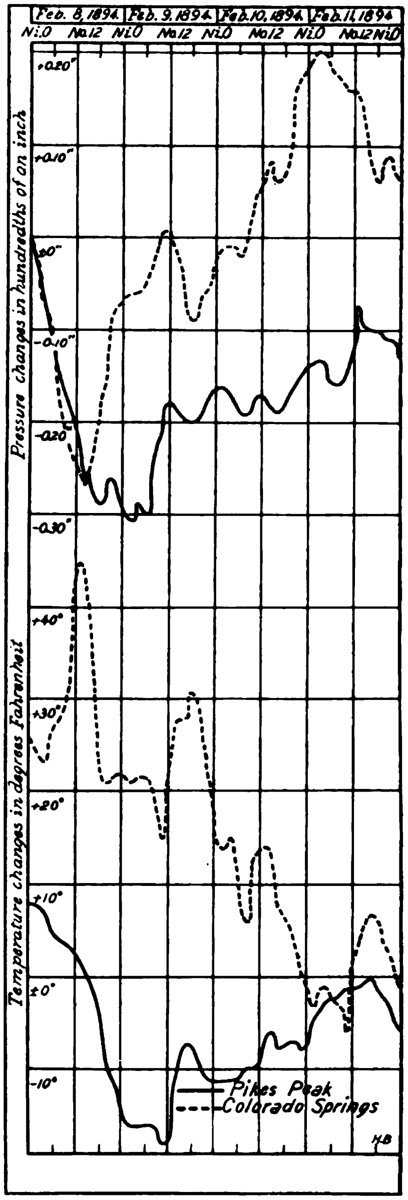

FIG. 2.—Synchronous changes in pressure and temperature at Pikes Peak and Colorado Springs, showing an inversion of temperature during the movement of an anticyclone southeastwards over the plains.

station was first upward then downward; in the second case it was the the reverse. In the case of the plains station the temperature fell very abruptly on February 20 from about 9° to −15° C. (48° to 5° F.) in six hours, and then remained low for the next two days. In the second case the fall was not so abrupt, but it was more persistent, being a considerable amount on the 8th, 9th, and 10th, and the minimum reached on the 11th was lower by 6° C. (11° F.) than the minimum on February 20.

The formula for the reduction of barometer readings to sea level contains an assumption as to the relation between temperature and pressure from which the fall in pressure at the upper station can be computed from the known change in mean temperature of the air column. The difficulty in the application of said formula lies in the fact that the mean temperature of the air column can not be satisfactorily determined from the mean of the temperatures at the upper and lower stations, respectively. The curves of figs. 1 to 5 show incidentally the great fallacy that is involved in the assumption that the mean temperature of the air column, so obtained, represents the true mean or even a fair approximation thereto.

Two other important examples of the influence on the temperature of the pressure distribution in the Rocky Mountains will be given.

1. In the first example, fig. 3, the center of the anticyclone was over the Great Basin, in the second, fig. 5, the center was to the northeast of the middle Rocky Mountain region, over the Dakotas, and eastern Montana. This latter disturbance of pressure gave cold northerly winds on the plains and caused a marked lowering of the temperature, so that an inversion was produced between the mountain and valley temperatures.

As has been previously stated the position of an anticyclone in the Great Basin insures fair weather and relatively high temperatures in Colorado, and this is clearly seen from the meteorological records of Pikes Peak. The latter station is then on the eastern margin of the anticyclone and the wind circulation over the Peak is controlled by the position of the center of the anticyclone, which, as before stated, is in the Great Basin west of the main chain. The winds on the Peak are then northeasterly and they continue from that direction so long as the center of the anticyclone remains unchanged. Paradoxical as it may seem these northeast winds cause a rise in the temperature on the high summits of the Rocky Mountains. The air which is thus brought across the mountain summits is apparently not surface air drawn up the mountain sides from the plains below, since it would then become colder with in-

creased elevation, and since, moreover, the direction of the wind at the lower station is rarely the same as at the upper station. The air which flows across Pikes Peak from the northeast, under the pressure distribution as above described, apparently comes from a region to the westward of Pikes Peak, and an altitude somewhat greater. How much of the warming is due to compression in its slow descent and how much to insolation in the cloudless skies of the high area is unknown. The Great Basin high area naturally dissipates in the course of a few days, but the relatively high temperatures over the Peak persist for a day or so longer, until one or more well-marked cyclones have passed eastward over the Peak.

2. A second example of the influence of the wind circulation in anticyclones is found when an anticyclone moves southeastward along, and partly over, the Rocky Mountains, with its center east-northeast of Pikes Peak. The surface wind in the eastern border of the anticyclone is northeast and is a very cold wind, contrary to the high wind experienced at Pikes Peak in the preceding example. It causes a very decided fall in temperature along the eastern foothills and on the plains abutting the Rocky Mountains on the east. In such cases the fall in temperature begins first below. As a result the temperatures on the mountain summits are sometimes greater than on the plains, as is illustrated in fig. 1. Here it will be seen that the temperature at the upper station was not affected by the surface wind.

The question as to the temperature distribution in cyclones and anticyclones has been a troublesome one for many years and now that the exploration of the upper air has become a feature of meteorological work in all countries the question again becomes a prominent one. Mountain observations in Europe and America led Dechevrens and Hann,[3] over 20 years ago, to demonstrate that the temperature aloft rises with rising pressure and falls with falling pressure at the same altitudes. Recent investigations of the temperature gradient in areas of high pressure and areas of low pressure by means of kite and balloon observations show that in Europe, at least, cyclones up to 5 kilometers average colder than anticyclones. The data on this point afforded by the Rocky Mountain stations seem to me somewhat inconclusive, although it appears that low pressure on the mountains is attended as a rule by low temperature. The converse, viz, that high temperature is associated with high pressure, is only partially true. In fig. 1 it will be seen that a rise in pressure on Pikes

[3]See Dechevrens L'Inclinaison des Vents Zi-ka-wei, 1881, Hann Ueber die Beziehungen zwischen Luftdruck und Temperatur variationen auf Berggipfeln. Met. Zeit., Jan., 1888, Vol. V, p. 7.

Peak was attended by a fall in temperature, as at low-level stations. The lowest temperatures experienced on the Peak occurred during a period of low pressure, but after the rise in pressure had set in.

To put the matter in statistical form I have, in Table 3, summarized the conditions at Pikes Peak and Colorado Springs during the notable warm and cold periods at Pikes Peak for the three winter months, December, 1893–February, 1894. The warm and cold periods, respectively, were determined solely by the departures of the daily mean temperatures at Pikes Peak for two or more consecutive days from the mean for the month. The daily mean temperatures and pressures used were mean values obtained from 24-hourly readings.

TABLE 3.—*Summary for warm and cold periods at Pikes Peak.*

	Warm periods at Pikes Peak; 8 in number; total length, 26 days.		Cold periods at Pikes Peak; 8 in number; total length, 42days.	
	Pikes Peak.	Colorado Springs.	Pikes Peak.	Colorado Springs.
Average departure of pressure from monthly means....	+3.30 mm.	+1.02 mm.	−3.81 mm.	−1.27 mm.
Average departure of temperature from monthly means....	+4.0° C.	+5.2° C.	−4.2° C.	−4.7° C.

Table 3 shows that not only on the top of Pikes Peak, but also at Colorado Springs, the warm periods are periods of relatively high pressure, and conversely the periods of low pressure are periods of low temperature.

If now, instead of grouping the departures by cold and warm periods, respectively, we compile the actual temperatures and corresponding pressures for the individual cold and warm days, respectively, we reach the results given in Table 4.

TABLE 4.—*Average temperatures and corresponding pressures for cold and warm days during January and February, 1893 and 1894, at Pikes Peak, Colo.*

Cold days.			Warm days.		
No.	Mean temperature.	Mean pressure.	No.	Mean temperature.	Mean pressure.
	° *C.*	*mm.*		° *C.*	*mm.*
5	−25.4	435	6	−12.3	442.7
12	−22.9	440	20	−12.1	447.3
4	−22.5	444	8	− 9.1	451.4

Finally, if the daily mean temperatures corresponding to the daily mean pressures be summarized, the latter in units of about 5 millimeters each, we arrive at the result shown in Table 5.

TABLE 5.—*Average pressures and corresponding temperatures on Pikes Peak and Colorado Springs, respectively.*

Pikes Peak.			Colorado Springs.		
Mean pressure.	Mean temperature.	No. of cases.	Mean pressure.	Mean temperature.	No. of cases.
mm.	° *C.*		*mm.*	° *C.*	
431.8 to 436.9	−23.6	8	597.0 to 602.0	+1.5	9
437.1 to 442.0	−19.3	30	602.3 to 607.1	−1.2	39
442.2 to 447.0	−16.2	48	....	.....	.....
447.3 to 452.1	−12.6	30	607.4 to 612.2	−0.2	52
452.4 to 457.2	− 7.0	2	612.4 to 617.2	−3.2	18

It will be seen from Table 5 that on the mountain top, as already pointed out by Dechevrens and Hann,[4] low temperature corresponds to low pressure, and vice versa, but on the low-level station at Colorado Springs the reverse is sometimes the case. While the mean values in the table indicate a progressive lowering of the temperature on the Peak with falling pressure, it should be remembered that the individual records do not point to any definite relation between temperature and pressure. The lowest temperature does not necessarily occur with the lowest pressure, nor the highest temperature with the highest pressure. On January 6, 1894, with a mean daily pressure of 436 millimeters on Pikes Peak, a mean daily temperature of −21.5° F. (−29.7° C.) was recorded. With still lower pressure three days preceding, i. e., on January 3, 1894, the mean daily temperature was only −6.1° F. (−21.1° C.). In general very low temperatures may occur under pressures varying from each other as much as 10 millimeters (0.393 inch).

As before stated the cyclone on the earth's surface at relatively low levels is composed of warm air in its front, more especially in its southeastern quadrant, and cold air in its rear, particularly in the northwest quadrant. In an anticyclone these conditions are reversed. It will be interesting to examine the records of Pikes Peak with reference to the conditions under which cyclones and anticyclones pass almost centrally over the summit.

The sea-level isobars which appear on the daily weather map for the Rocky Mountain region are admittedly defective, perhaps more so at one time than at another, on account of the difficulty of assigning an appropriate mean temperature to the imaginary air column between sea level and the upper station. Some idea of the complexity of the problem is suggested by the data of Tables 6 and 7 which show the actual changes of temperature at base and summit stations. The sea-level pressures in these tables were scaled from the daily 8 a. m. simul-

[4] Meteorologische Zeitschrift, Vol. V, 1888, p. 7.

taneous weather maps for January and February, 1893, and for the same months of 1894. Only those dates were selected on which an area of low pressure (Table 6) or an area of high pressure (Table 7) passed across Colorado.

TABLE 6.—*Meteorological data for Pikes Peak (8 a. m., 75th meridian time) when low pressure (cyclone) is passing over the Peak.*

Date.	Pressure.		Temperature.		Wind.	
	Sea level isobar.	Observed on Peak.	Observed at 8 a. m.	Departure from monthly means.	Direction.	Velocity.
1893.	*Inches.*	*Inches.*	°*F.*	°*F.*		*m. p. h.*
January 25	29.90	17.55	10	+ 2.9	sw.	52
January 28	29.70	17.27	7	− 0.1	sw.	7
January 31	29.50	17.24	11	+ 3.9	sw.	15
February 2	30.00	17.15	− 7	− 8.1	sw.	20
February 5	29.70	17.45	9	+ 7.9	sw.	18
February 9	29.60	17.34	11	+ 9.9	sw.	13
February 13	29.60	17.17	− 1	− 2.1	ne.	5
February 14	30.34[a]	17.28	−10	−11.1	nw.	4
February 26	29.80[b]	17.16	− 2	− 3.1	sw.	33
February 27	30.06[a]	17.05	−14	−15.1	nw.	12
1894.						
January 2	29.80	17.43	4	+ 3.1	sw.	34
January 3	29.90	17.15	− 3	− 2.1	s.	11
January 5	29.90	17.05	−13	−12.1	w.	13
January 30	29.90	17.51	9	+ 8.1	w.	55
February 18	29.96	17.35	− 3	− 2.9	w.	20
March 4	29.50	17.17	− 1	− 9.3	s.	34
Means	29.79	17.27	0.4	− 1.9	sw.	21.6

[a]Center of cyclone about 600 miles eastward.
[b]Center of cyclone about 300 miles eastward.

TABLE 7.—*Meteorological data for Pikes Peak (8 a. m., 75th meridian time) when high pressure (anticyclone) is passing over the Peak.*

Date.	Pressure.		Temperature.		Wind.	
	Sea level isobar.	Observed on Peak.	At 8 a. m.	Departure from monthly means.	Direction.	Velocity.
1893.	*Inches.*	*Inches.*	°*F.*	°*F.*		*m. p. h.*
January 7	30.46	17.82	0	− 7.1	ne.	29
January 12	30.38	17.49	− 4	−11.1	ne.	49
January 15	30.52	17.48	− 7	−14.1	nw.	18
January 16	30.40	17.54	− 1	− 8.1	nw.	10
January 18	30.30	17.49	1	− 6.1	ne.	18
January 22	30.38	17.78	9	+ 2.1	w.	21
January 23	30.35	17.77	5	− 2.1	n.	7
February 3	30.55	17.62	− 4	− 5.1	sw.	65
February 7	30.62	17.61	− 8	− 9.1	w.	52
February 14	30.30	17.28	−10	−11.2	nw.	4
February 18	30.48	17.72	− 1	− 2.1	n.	34
1894.						
January 9	30.44	17.43	−12	−11.9	nw.	22
February 3	30.30	17.30	−14	−13.9	e.	7
February 11	30.50	17.28	− 2	− 1.9	sw.	11
February 13	30.30	17.28	−12	−11.9	nw.	8
February 14	30.46	17.39	−18	−17.9	ne.	24
February 23	30.80	17.57	− 4	− 3.9	e.	15
Means	30.48	17.55	− 5.1	− 8.2	nw.	25

The data in Tables 6 and 7 are, first the date; second, the sea-level pressures as scaled from the daily weather map for 8 a. m.; third, the actual pressures on Pikes Peak as read from the mercurial barometer and corrected for instrumental temperature and scale error but not for local gravity; fourth, the actual 8 a. m. (75th meridian time) temperatures on Pikes Peak; fifth, the departure of these actual temperatures from the mean of the month; sixth, the direction of the wind at Pikes Peak; seventh, the velocity of the same in miles per hour at 8 a. m., 75th meridan time.

The correction to reduce the 8 a. m. temperature at Pikes Peak to the 24-hour mean in January is $-1.3°$ F., in February $-0.5°$ F.

The temperatures in and near the centers of cyclones that pass across the Rocky Mountains appear to be extremely variable. On the plains east of the Rocky Mountains the surface winds in front of a cyclone are, as a rule, warm southerly to easterly. On Pikes Peak the most frequent wind in advance of a cyclone is from the southwest. Southeasterly winds on the Peak rarely occur at any time. Any surface wind from an easterly quarter must ascend the eastern slope of the mountains through an elevation of about 2440 meters (8000 feet) before reaching the summit of Pikes Peak.

From considerations of topography alone it seems not likely that the indraught of warm surface air from lower latitudes in front of a cyclone prevails at Pikes Peak, yet the high temperatures that sometimes occur in the southern part of a cyclone, see those of January 25, 28, and 31, and February 9, 1893, Table 6, make it seem possible that surface conditions sometimes obtain even at the altitude of Pikes Peak. If the surface air from the southwest is carried up and across Pikes Peak there must be a material cooling by expansion.[5] On the other hand in certain well-developed cyclones very low temperatures prevailed, as on February 14 and 27, 1893, and January 5, 1894. The very low temperatures on the two dates first named can be explained by the fact that at the time of observation Pikes Peak was in the region of northwest winds, the center of the cyclone at the surface being far to the eastward. The severest cold at the Peak occurs as before stated after the barometer has begun to rise. The barometer at the summit station at times lags considerably behind that of the base station.[6] This fact is illustrated by the examples given under February 14 and

[5]Ascents of 3000, 4000, and 5000 feet correspond to adiabatic cooling of dry air to the extent of 17.0°, 22.9°, and 28.6° F., respectievly.

[6]As first pointed out by Loomis from a consideration of the observations on Mount Washington.

27, when the rise at sea level in the preceeding twenty-four hours was much greater than at the summit. In the last-named case the lowest pressure on the summit was reached twenty-four hours later than on the plains at Colorado Springs.

The average temperature in the sixteen lows enumerated in Table 6 is slightly higher than in the same number of highs that are given in Table 7, contrary to the experience at mountain stations in Europe. As we have elsewhere shown low pressure on the Peak corresponds on the average with low temperature, and vice versa, and this law seems to be universal. But on account of the much greater rapidity with which changes in pressure and temperature take place in the United States as compared with Europe the results in all cases do not agree in all details.

3. Areas of high pressure which lodge in the Great Basin, and show no tendency to cross the Rocky Mountains, cause rising temperature with northeast winds and fair weather on Pikes Peak, while on the other hand areas of high pressure which move southeastward along the eastern slope of the Rocky Mountains produce very low temperatures at the base of the mountain range while the temperatures on the summits finally sink, although at first uninfluenced by the fall going on below. Highs moving as described in the latter sentence presuppose low pressure on the western side of the mountains. A peculiarity of this pressure distribution is the high westerly winds which prevail on Pikes Peak. Of course the sea-level isobars show only high pressure east of the mountains, yet the winds on the summit of the Peak blow with storm violence directly toward the areas of high pressure. Examples of this phenomenon are given in the data for February 3 and 7, 1893. On these dates the temperature gradient between Pikes Peak and Colorado Springs was 0.43° and 0.41° C. per 100 meters.

A third case may also occur, viz, in which areas of high pressure move nearly broadside southward on both sides of the range and along its summit. This last case brings the lowest temperatures of all to the mountain tops. Examples of this third case are given in the data for January 9, and February 13, 1894.

In general the temperature that is experienced in an anticyclone in the Rocky Mountain region seems therefore to depend not so much on the absolute value of the pressure as on the distribution of pressure over surrounding regions.

High winds may be experienced on Pikes Peak from any point between southwest and north. East or southeast winds rarely blow. Northeast winds are persistent and sometimes high when an anticy-

clone occupies the Great Basin. The pressure distribution favorable to continued high southwest winds on the mountain summits is as follows: pressure is low west of the Rocky Mountains with the central depression over eastern Oregon and southern Idaho; the sea-level isobars loop southeastward over Colorado and the Plains States to the eastward. Pressure in Montana and the Dakotas need not be high. The stormwinds generally continue for a period of at least twelve hours and the velocities average from 60 to 80 miles per hour. Some of the high velocities are as follows: on November 29-30, 1893, the average wind travel at Pikes Peak was 79 miles per hour from the southwest for twelve hours; on January 27, 1893, the same velocity from the west prevailed for twelve hours, and on January 20 a wind travel of 83 miles per hour from the north was recorded for a period of twelve hours; the total travel of the wind by the Robinson anemometer, uncorrected, was 999 miles in the twelve hours. Life on the mountain during these paroxysms of nature is possible only in the most substantial sort of structure. The mountain top at times of hurricane wind is generally immersed in dense fog, frost feathers form to incredible distances to the windward of exposed objects, and existence without shelter is impossible. While the wind is blowing with hurricane velocity on the mountain top, it is scarcely stirring, so to speak, on the plains below in the shadow of the mountain, but after the high winds have continued for some time on the mountain top, say eight to sixteen hours, depending on circumstances, movement is communicated to the surface air on the plains below and it is suddenly set in motion. The ratio of the number of high winds at Pikes Peak of 60 miles an hour and over to the stormwinds at Colorado Springs of, say 30 miles an hour and over, is about as 2.1 to 1. The average of 20 cases of winds of 60 miles per hour or over at Pikes Peak during the period December 1, 1893, to March 31, 1894, gives, for duration, ten hours, and for velocity, 71.8 miles per hour. The same count for Colorado Springs, considering 30 miles per hour as a stormwind at that station, gives as an average period of seven hours and an average velocity of 33.8 miles per hour.

The high winds on the summit generally precede the cyclone, being greatest when the center of the cyclone is 300 or 400 miles west of Pikes Peak. The velocity falls off very decidedly as the center approaches Pikes Peak, averaging only 21.6 miles, as shown in Table 6. In an anticyclone (see Table 7) the velocity appears to be a little greater, viz, 25 miles. Both velocities are probably too high, owing to the difficulty of locating the center of the cyclone or anticyclone with reference to Pikes Peak.

In only one case out of 20 did the beginning of the stormwinds occur coincidently at Pikes Peak and Colorado Springs. And in but a single case did the storm velocity at the lower station begin *first*. On this occasion a high wind from the northwest began at Colorado Springs about 2:00 a. m., January 20, 1894, and continued for eleven hours at an average speed of 45 miles an hour. Four hours later a wind averaging 83 miles per hour from the north set in at the Peak and continued for twelve hours. The cause of these high winds is not clear. Small windstorms, mostly from the north and northeast, are occasionally experienced at Colorado Springs which do not extend to the summit of Pikes Peak, and vice versa, local windstorms are experienced at Pikes Peak which do not extend down to the plains.

The high westerly winds at the summit that precede cyclones approaching Pikes Peak from the west do not seem to descend the mountain side to the vicinity of Colorado Springs, except in the case where the cyclone moves southeastward across the Dakotas at a distance of about 600 miles northeast from Pikes Peak. In that case there seems to be a true descent of the winds to the plains close to the eastern foothills, and the winds both on the Peak and at Colorado Springs are relatively warm. If the warmth was confined to the low level station it might be said at once that here we have to do with warming by compression. It seems quite probable that the high southwest winds that so frequently blow across the high mountains of eastern Colorado descend as warm winds over the plains some distance to the eastward, but not so near the mountains as are Denver and Colorado Springs. In the Monthly Weather Review for April, 1908, page 87, Mr. L. H. Daingerfield reports upon the occurrence of chinook winds from the west at Pueblo, Colo., when the pressure distribution is similar to that which causes high westerly winds across Pikes Peak. Pueblo is not more than 40 miles due east from the nearest foothills of the Rocky Mountains and about 40 miles south-southeast from Colorado Springs.

We have previously made reference to westerly winds that blow across the mountains apparently from a region of low pressure into a region of high pressure. The winds at Rocky Mountain stations do not always closely conform to the isobars, but a considerable part of the divergence may be ascribed to local topography. The most striking departure of the wind is observed in connection with the movement southeastward of large anticyclones which enter the United States from the British Possessions north of Montana. Under ordinary conditions the Rocky Mountains form the western limit of such anticyclones, and pressure is always lower to the westward over the States of Washington,

Oregon, Nevada, and California. In the United States the nearest approach of the Rocky Mountain chain to the Pacific is found in western Montana and Idaho; and consequently the barometric gradient, toward the westward, as determined from sea-level isobars, is very great when the interior region is occupied by an anticyclone and a cyclone is central off the Washington coast. On February 3, 1893, a difference of pressure of an inch (25.40 mm.) existed between the Pacific coast and the Rocky Mountains in Idaho, a distance of less than 400 miles. Farther south the mountains bend away from the coast toward the interior of the continent, and accordingly the pressure gradient becomes less.

Observations on the movements of the clouds and the wind on the mountains of Idaho and Montana show that, while the preceding pressure conditions for sea-level isobars prevail, the winds at no great height above the mountains are moving from the west, notwithstanding the very great sea-level pressure gradient to the contrary. On Pikes Peak, when such pressure conditions obtain, the wind is almost invariably from the southwest. On the eastern slope of the mountains, coincident with the prevalence of westerly winds across the mountains, cold northerly winds precede the anticyclone, and for a time blow with great violence. In addition to the gradient produced by horizontal temperature differences there is a gravitative impulse on account of the surface slope toward the Mississippi Valley and the Gulf of Mexico, which adds to the southward velocity of the wind. Meanwhile the air over the Rocky Mountains, as clearly shown by observations at Pikes Peak and other points, is flowing directly over the top of the anticyclone and in all probability supplying the deficit in air in the upper layers of the anticyclone caused by the southward movement of the surface air. The surface air moves southward faster than does the air at the level of Pikes Peak. The Pikes Peak observations show unmistakably that the rush of cold air southward in the front of a cold wave over the plains does not extend upward to the level of the Peak. The temperature observations at the plains stations of Denver, Colorado Springs, and Pueblo also show that in an anticyclone, as soon as the surface wind dies down and insolation becomes effective, the surface temperature rises sharply. While the greater portion of this observed heating must be ascribed to insolation in the dry, clear air of the plains there is reason to believe that dynamic heating may also be operative in a greater or less degree.

Summarizing the foregoing and also including some observations that have not been specifically touched upon, we conclude as follows:

1. In general the temperature changes at high and low level stations are nearly synchronous in point of time and similarly directed, but in particular cases the temperature may rise at one station and fall at the other, or vice versa, although the horizontal distance between them is small.

2. Any abnormal course of the temperature between a mountain station and a near-by low-level station can generally be explained by considering the pressure distribution over surrounding regions to a distance of at least 1000 miles from the stations. The effect of topography on the interchange of air between cyclones and anticyclones is also to be considered.

3. An inversion of temperature between Corona and Denver, Colo., occurs most frequently when the temperature of the lower station, Denver, is unduly lowered by cold northerly or northeasterly winds that issue from the front of an area of high pressure over Montana at a time when cyclonic conditions prevail from the mountain summits westward to the Pacific.

4. The high southwest to west winds which sometimes prevail on such mountain summits as Pikes Peak and Corona indicate the early formation of a cyclone in the northern part of the Great Basin or over the mountains to the eastward thereof; it being understood that such cyclone is an offshoot of a parent cyclone which is central off the coasts of Washington and Oregon.

5. In the cold season the temperatures on these mountain summits fall whenever a cyclone passes eastward across the mountains, or southeastward from Montana to Kansas, regardless whether or no an anticyclone appears within the field of observation. Extremely low temperatures on the mountains occur in connection with one or more days of low pressure. The minimum temperature is not coincident with lowest pressure, but occurs during the rise in pressure from a minimum to a maximum and before the maximum is reached. A well-marked anticyclone may pass southeastward along the eastern slope of the Rocky Mountains without affecting the temperature on summits above 10000 feet (3050 m.). Low temperatures on the mountain tops occur when anticyclonic conditions exist on both sides of the mountains and extend westward to the Pacific.

6. When an anticyclone reaches the Great Basin and lodges there temporarily, it affects the wind circulation on the summit of the Rocky Mountains of central Colorado and is attended by high temperatures and fair weather.

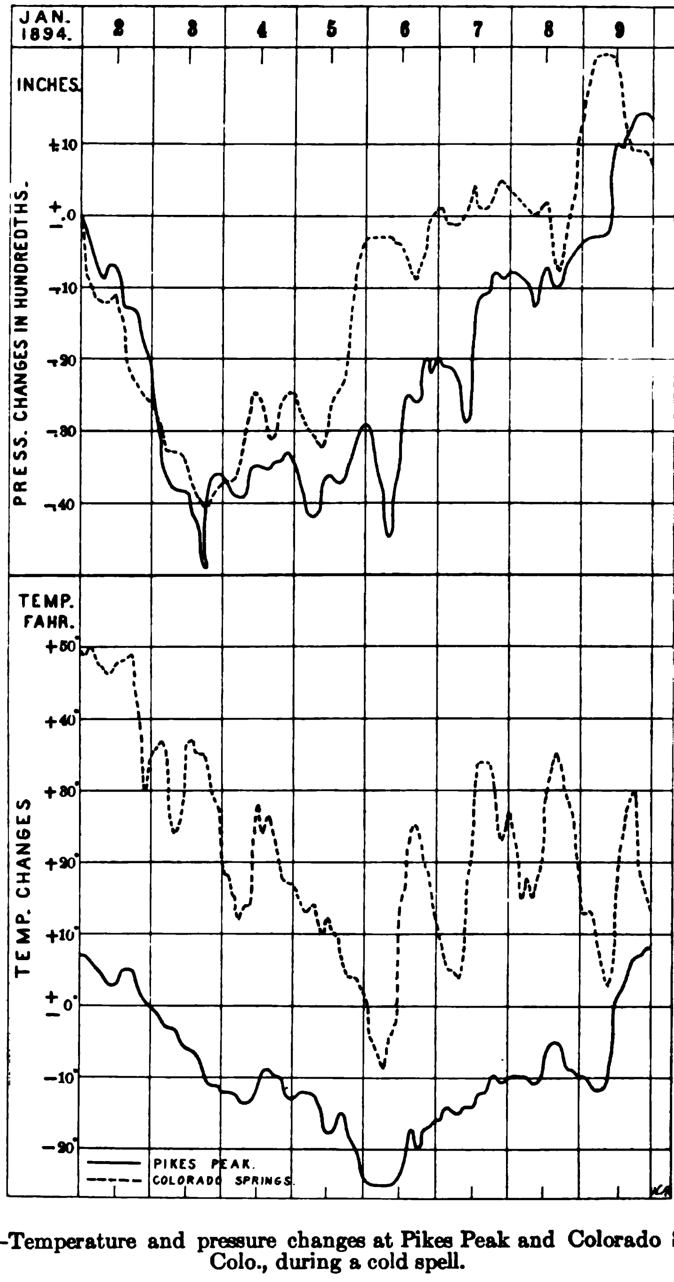

FIG. 4.—Temperature and pressure changes at Pikes Peak and Colorado Springs, Colo., during a cold spell.

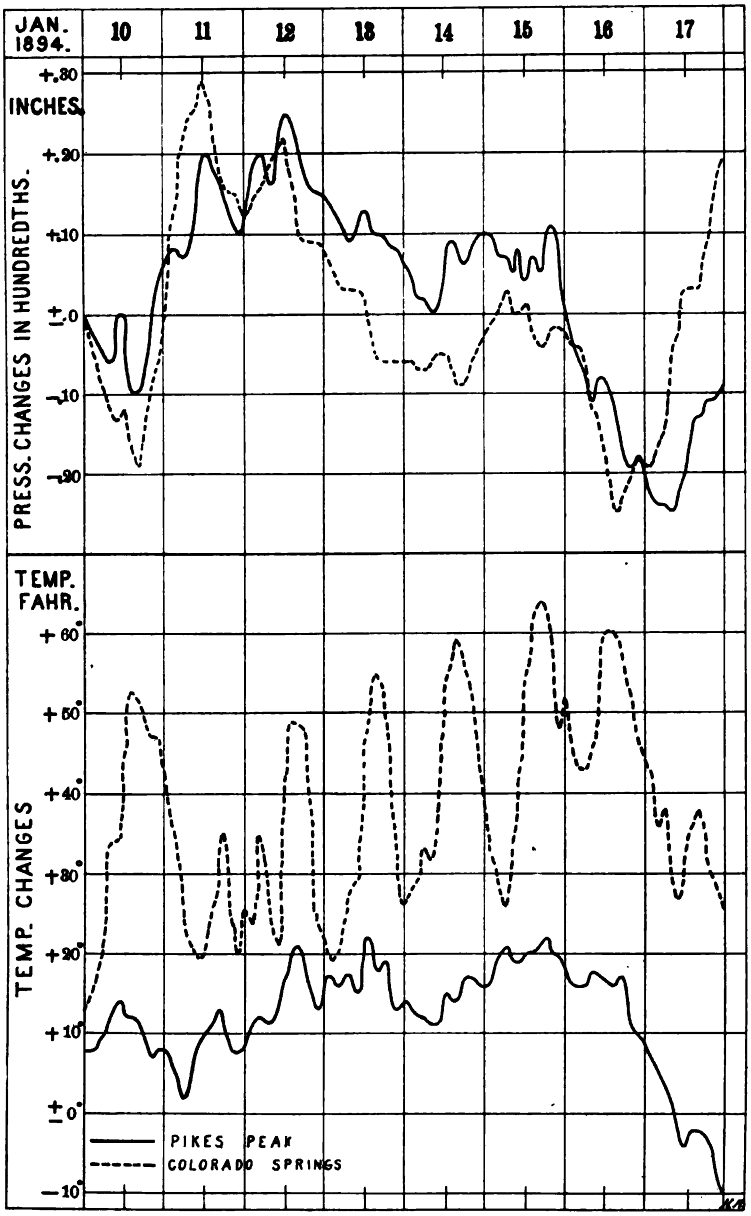

FIG. 3.—Synchronous temperature and pressure changes at Pikes Peak and Colorado Springs, Colo., during a warm spell. Center of high in Great Basin; northeast winds on Pikes Peak.

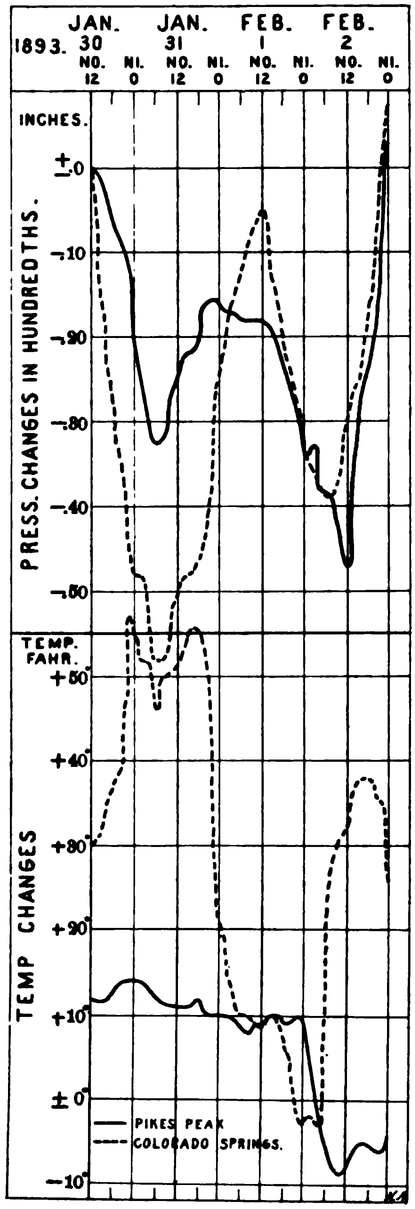

FIG. 5.—From noon, January 30, to midnight, February 2, while a chain of lows from the north Pacific coast was moving southeastward across the Rocky Mountains; temperature fall produced by high that comes down from British America. The surface cooling and rising pressure did not extend to summit of the mountains; high moved rapidly northeastward.

7. The high mountains of central Colorado seem to form a "saddle" in the anticyclones that pass across them. In other words when an anticyclone tends to move east-southeastward from the Great Basin there nearly always appears to be a weakening in the sea-level pressure when crossing the high mountains of Colorado, and two centers of high pressure appear, one over the Great Basin with its center at Salt Lake and the other in Colorado, east or southeast of the mountains, with a difference in pressure between them of at least one-tenth of an inch (2.54 mm.). The saddle over Colorado generally deepens with higher temperatures and makes an easy path for a fresh low from the region north of Montana. This saddle may be due to descending winds on the eastern mountain slope, since the sea-level pressures are mainly determined from stations at Cheyenne, Denver, and Pueblo, and there the temperature abnormalities at times are known to be very great.

Figs. 1 and 2 illustrate the simultaneous temperature and pressure changes at Pikes Peak and Colorado Springs during a temperature inversion.

Figs. 3 and 4 show the temperature and pressure changes during the prevalence of periods of high and low temperatures, respectively.

Fig. 5 shows the temperature and pressure changes in connection with the advance of a chain of cyclones from the North Pacific. Note how the temperature at the Peak remained steady on the passage of the first area of low pressure, but fell steadily in connection with the second.

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(XI) STUDIES IN THE GENERAL CIRCULATION OF THE ATMOSPHERE—*Continued.*

By F. H. Bigelow. (Dated March 12 and September 27, 1910.)

RADIATION FROM THE SUN AND TEMPERATURES IN THE EARTH'S ATMOSPHERE.

In the Monthly Weather Review, January, 1902, will be found two diagrams of black body radiations computed by the Wein-Planck formula for solar temperatures, 4000° to 8000° T., and for terrestrial temperatures, 198° to 383° T. It is seen that with the increase of the solar temperature there is a corresponding rapid increase in the radiations of the short wave-lengths, zero to 0.40 μ. It is probable that in the complex circulation of the enormous solar mass there are produced at irregular intervals of time flushes of heat covering certain regions along the sun's equatorial belt, above the normal temperature, and certain other regions of depressed temperature, the two series of warm and cold areas alternating with each other. The warm regions may pertain to ascending convection and the cool regions to descending convection, though by no means very closely identified with the observed sun-spot areas. The generation of the solar prominences seems to be a direct product of such vertical convections. If we assume that the solar surface really consists of areas of different temperature, an assumption that is rendered plausible by the violent circulations noted in the solar atmosphere, then it follows that the solar radiations will be emitted in bundles of rays, some rich in short wave-lengths from the hot areas, others poor in short waves from the cold areas, in proportion to the effective temperatures of the respective emissions. These rays from alternate hot and cool areas proceed out into space, and the earth in its orbit encounters the several kinds as they are emitted by the sun. Now all solar radiation falling upon the earth's atmosphere seems to undergo three distinct processes of depletion, as follows:

1. A certain percentage of the rays is deflected and scattered by the molecules of the air, the ice crystals, the dust particles, so that they are reflected back into space, adding to the albedo of the earth as a planet. This percentage of depletion is often spoken of erroneously as absorption, being really mechanical reflection of a multiple type. The transmitted portion of the radiation is measured by the actinometer and the bolometer at the earth's surface, and is found to decrease with increase in the length of the path of the ray through the atmosphere. It is

found to vary daily with every high sun and low sun observation; it is found by observations on Mount Whitney, Mount Wilson, and at Washington to decrease with the depth of the atmosphere. This depletion is chiefly concerned with the short wave-lengths which are most influenced by molecular reflection and scattering, the result being that the normal hot body radiation curves are heavily and progressively depleted in their progress through the atmosphere down toward the earth's surface.

2. There seems to be a part of the very short wave energy which is transformed by absorption in the rarified gases of the outer layers of the atmosphere. The transformed energy of radiation reappears as heat in the isothermal layer, and as electric currents measured by the large and small perturbations of the earth's normal magnetic field, through the processes of ionization. The short waves at high temperatures appear capable of ionizing rarified gases, and the electric ions in motion produce currents and magnetic fields that disturb the normal field. In my "Report on the Eclipse, May 28, 1900," "Eclipse Meteorology and Allied Problems, pp 132, 133," and in my paper "Diurnal periods of the terrestrial magnetic field and the periodic disturbances," I expressed my doubts as to the important part supposed to be played by the conjectural bombardment of the earth by corpuscles assumed to be transported from the sun to the earth producing the mechanical pressure of radiation. It is necessary to separate the ionization effects due to "short wave radiation" and those due to "corpuscles in bombardment," if it can be done. The source of variable short wave energy is obvious, and its transformation into the ionized electric currents and magnetic field is entirely probable, as testified by the auroras and the magnetic disturbances. If this view is made the basis of further solar research, we may succeed in the additional desirable effort, to cause students to observe other sources of disturbance on the sun's disk than the visual solar spots.

3. A further depletion and transformation of energy occurs in the lower atmosphere, where more of the short wave-lengths are absorbed on the crest of the "black body curve," especially by the aqueous vapor and the denser gases which select certain bands from the spectrum. This type of transformed energy in the part of the air which is more or less charged with aqueous vapor produces free ions, due to the disintegrated vapor molecules, and these ions are redistributed by convection currents, in conformity with effects noted in the observed diurnal periods. It was shown in the paper above mentioned how close is the relation between the electrical and magnetic effects in the *lower strata*

of the atmosphere, and the observed diurnal and semidiurnal periods of temperature, pressure, density, and wind vectors. *Since all of these diurnal and semidiurnal periods disappear within one or two miles of the earth's surface it follows that the correlative electrical and magnetic effects must be caused by processes of transformation and transportation in the lowest strata of the atmosphere,* and that they can not be attributed to the incoming corpuscular bombardment which is doubtless almost entirely screened off in the outer layers, that is, in the isothermal region. If this progressive sorting and transformation of energy can thus be divided principally into upper and lower portions, the upper in the isothermal layer and the lower in the convectional layer near the ground, it follows that the intermediate region from 3000 to 13000 meters above the surface is for the most part translucent and diathermanous to the incoming radiation.

THE EARTH'S OUTGOING LOW TEMPERATURE RADIATION.

The energy of the incoming radiation, after absorption by the gases and aqueous vapor or by the earth, radiates outward at very low temperatures and long wave-lengths. To separate for any given unit mass of air, at any place in the atmosphere, the temperature effects due to the incoming and the outgoing radiations, respectively, is a very difficult procedure. Furthermore, the transportation of the temperature effects, by vertical convections or by horizontal currents, must be considered. The diurnal vertical convection, with its attendant physical effects, ceases at about two miles in elevation in all latitudes; the cyclonic vertical convection in the Temperate Zones makes a mixed circulation up to 10000 meters; the convection is upward in the Tropics generally, but downward in the Temperate Zone from about the same elevation. To apply any simple interpretation of the Kirchhoff Law is merely trivial in character in this case. Bouguer's Law and Stefan's Law in combination apparently are in operation simultaneously, though in exactly what way is not yet known. There are a series of complex functions connecting the radiation pressure in the ether and the radiation pressure in gases, through the processes of ionization and temperature. The elucidation of this subject requires a special research, and it is proposed to devote particular attention to it in the immediate future.

THE CIRCULATION IN THE SUN.

The observations on the sun's disk indicate an apparent conflict of principles. On one hand, the temperatures appear by surface measurements to be uniform in all solar latitudes from the pole to the equator;

on the other hand, there is a great change in the angular velocity of rotation, i. e., 26.70 days near the equator of the photosphere and 31.00 near the poles; or 26.00 days in the outer layers of the chromosphere and 29.00 days near the poles. These facts are contradictory because difference in circulation depends in all atmospheres upon difference in temperature. Hence, it may be inferred that the deep-seated layers in the sun have a wide difference in temperature, while the superficial layers are at nearly the same temperature, as in the case of the earth, where the lower layers differ widely in temperature while the outer or isothermal layer would seem to an observer from the outside of the earth's atmosphere to be uniform. This fact refers us to an earlier paper, Monthly Weather Review, January, 1904, where one relation of temperature and velocity is found for the given gradient or slope connecting neighboring points. Some preliminary computations indicate that the system of temperatures and circulations in the sun is the inverse of that on the earth, due to the difference of the respective seats of the sources of the energy. The data in Tables 1-6 of this present paper afford the means of making progress in this class of closely related problems. It is now desirable for direct observations to make improvements in the temperatures here assumed, as it is easy to do in detail though generally those here assumed produce approximately the velocities known to exist in the earth's atmosphere.

(XII) PHOTOGRAPHS OF THE AURORA BOREALIS AND A NEW METHOD OF MEASURING ITS ALTITUDE.

By CARL STOERMER. (Dated June 13, 1910, translated by the Editor.[1])

As is well known the problem of taking successful photographs of the aurora borealis presents great difficulties because of the feeble light of the aurora as well as because of its mobility which necessitates reducing the exposure to a few seconds only. So far as I know there exists only one photograph of short exposure (7 seconds), i. e., that taken by Brendel at Bossekop of the aurora of February, 1892. (See Baschin, Met. Zeit. 1900, page 278–280.)

During the past year I have made a series of experiments in order to determine on the best possible objectives and plates for photographing the aurora borealis. Finally I chose a cinematographic objective of 25 millimeters diameter with a focal distance of 50 millimeters and the plates "Lumiére a etiquette violette." Thanks to this choice I have been able to solve the problem in question. During an expedition to Bossekop in February and March, 1910, I have taken in all about eight hundred auroral photographs among which about one-half were successful. The duration of the exposures varied between a fraction of a second and 20 seconds, depending on the brightness and motion of the aurora. When once this instrumental problem is resolved, one has therefore an excellent method of measuring the altitude of the aurora and its location in space. In fact one has only to photograph an aurora simultaneously at two stations that are connected by telephone and to compare the apparent locations of the aurora with reference to the stars on both plates; knowing the time and the optical constants of the objective one has all the data needed for calculating the altitude and location of the aurora and that too with great precision.

The stations that we chose are Altenkirke (longitude 23° 15′ 5″ east of Greenwich, latitude 69° 57′ 51″) and Upper Altenskole (longitude 23° 16′ 4″, latitude 69° 55′ 34″); the distance between them was 4.3 kilometers.

Among the sixty-four successful photographs taken simultaneously at those locations we reproduce here the four following without any artistic retouching.[2]

[1] An advance copy of Stoermer's remarkable achievement is sent the Editor for use in this Bulletin.

[2] These four pairs of simultaneous photographs showing the auroral spots and the neighboring brighter stars are not here reproduced, as they will undoubtedly be published hereafter in a more complete report.—EDITOR.

Fig. 1 represents a feeble or quiescent aurora having the form of a vibrating spot taken at 8 h. 24 m. 46 s., Greenwich time, March 1, 1910; the time relates to the beginning of the exposure, which lasted 20 seconds. By calculation the resulting altitude of this spot, whose apparent location lay between the stars α and β Ursæ Majoris, is determined to be about 166 kilometers with a probable error of about 10 kilometers.

Fig. 2 is a magnified reproduction of the photograph of an auroral drapery in the neighborhood of the Pleiades, March 9, at 10 h. 26 m. 22 s. with an exposure of 3 seconds.

The aurora in the neighborhood of the Pleiades was distant about 200 kilometers and had an altitude of between 50 and 60 kilometers. The drapery made a great fold which caused its increased brightness. The white spot on the right-hand side of the photograph was due to a defect in the sensitized plate.

Fig. 3 represents an auroral arch passing through the zenith on March 14 at 6 h. 34 m. 22 s.; duration of exposure 10 seconds; altitude 190 kilometers in the direction of β Ursæ Majoris.

Fig. 4 represents also an auroral arch of the same date March 14 at 8 h. 32 m. 50 s. Altitude 120 kilometers in the direction of the star ξ Ursæ Majoris.

We are convinced that the systematic application of this new photographic method can not fail to give results of the highest importance to the study of auroras.

(XIII) IMPROVING THE FORECASTS.

By A. G. McAdie. (Dated San Francisco, August 19, 1910.)

In Bulletin No. 4, of the Central Meteorological Observatory of Japan, Tokio, 1910, appears a paper by T. Okada, Chief Forecaster of the Japanese Weather Bureau, on Centers of Action of the Atmosphere in the Far East. The paper is of considerable interest to those engaged in forecasting because it represents the views of a practical forecaster and is in its essence an attempt to apply in the daily forecasts the correlation of weather conditions and pressure abnormalities over a large area and covering a period of several weeks or even months.

Meteorologists have been for many years aware of certain weather anomalies existing at times of marked departures from normal conditions in the so-called permanent pressure areas. The term "Centers of Action" has been used to indicate the action and interplay of the large pressure areas which are found to exist over continents and oceans, varying with the seasons. In the Far East these great maxima and minima are, as stated by Okada, in winter a Siberian maximum with a deep minimum south of the Aleutian Islands and in summer the great Pacific anticyclone and the Asiatic continental low. Weather anomalies in the Far East and especially in Japan, according to Okada, are intimately related to the position and intensity of these centers of atmospheric action. He states[1] that—

> During the winter the abnormal rise in pressure over the Asiatic Continent is invariably attended by abnormally cold weather in Japan and on the coast of the continent. When the Siberian anticyclone becomes intensified or extends toward the south or southeast the barometric gradient over this country becomes very steep. This is especially the case when a cyclonic center from the continent has traveled over the Japan Sea and passed away into the Sea of Okhotsk. In consequence of this barometric distribution a cold northwesterly monsoon sets in, and brings cold air from the interior of the continent. The cold weather continues as long as the barometer stands higher than the normal over the continent.

With a view of detecting a positive relation between the mean values of pressure and temperature Okada has used the data for Zi-ka-wei, 1873 to 1903, and the Nagasaki observations from 1879 to 1904. As a measure of the variation in the intensity of the "grand center of action of the atmosphere in Siberia" Okada uses the departures of the pressure from the normal mean at Zi-ka-wei. The method of determining the

[1] Op. cit. p. 2, § 3.

correlation between pressure and temperature is as follows: For any given month tables are constructed, the first column containing the pressure; the second, the departure of the pressure from the mean; the third, the squares of these departures; fourth, the temperature; fifth, the departure of the temperature from the mean; sixth, the squares of these departures; and seventh, the products of the pressure and temperature departures. It appears that a low temperature in November and December is associated with an abnormal rise of pressure in 70 per cent of the periods considered. For Nagasaki, using the same method, it is found that an abnormal rise in pressure is accompanied by a fall in temperature in about 77 per cent of the periods considered. Moreover a rise of pressure at Zi-ka-wei is found to be associated with a fall in temperature at Nagasaki.

There is an interesting statement of the probable control of weather conditions in Japan by the movements of the Pacific high. Late in the spring or early summer the existence of a pressure maximum over the northwestern part of the Pacific Ocean and the Sea of Okhotsk results in cool weather over the northern part of Japan. But when this high pressure swings to the east and overlies the ocean south of the Kuriles there is an inflow of rather warm air and a corresponding rise in temperature over northern Japan.

Okada also calls attention to the fact that high pressure in northern and central China is associated with heavy rain over northern Formosa. The connection is so close that he makes use of the relation with some degree of success in the daily weather forecasts. During the winter months cloudy or rainy weather must be forecast for Keelung whenever there is a marked rise of the barometer at Shanghai or any locality in the lower Yangtze Valley.

To American forecasters, and more particularly those forecasting for the Pacific slope, the movement of these pressure areas is of great importance. While the daily maps still lack adequate data concerning pressure values over the North Pacific, we can to some degree by means of the Alaskan stations, wireless reports from ships at sea, and observations of the Japanese and Philippine weather stations, obtain approximate knowledge. It is a source of regret that observations can not be obtained from points on the Aleutian Islands; observations from points in the interior of Alaska are also desirable. Two general laws have been practically established for the north Pacific coast. These, as published by me in Monthly Weather Review, April, 1908, page 100, are as follows, with a few recent modifications:

(A) When the continental high overlies Oregon, Idaho, Utah, and Nevada the general drift of the surface air is from the north or northeast; and such a circulation favors fair weather, with little precipitation. Individual highs are likely to move slowly eastward. Individual lows are restricted to northern districts, and pass, as a rule, eastward without southerly extension.

(B) When the North Pacific low extends well southward along the Oregon coast and the continental high overlies Assiniboia and Montana, or is apparently farther east than in a normal season, the general drift of the surface air in California and on the Pacific coast is from south or southeast. Frequent and heavy rains result west of the Sierra with heavy snow in the mountains. Individual highs appear with little warning north and east of the Kootenai and move, as a rule, slowly southeast. Individual lows appearing over Vancouver Island or the north coast of Washington deepen and extend southward rapidly, the rain area reaching northern California in twelve hours, the central coast in twenty-four hours, and the coast south of Point Conception in thirty-six hours.

The above laws were deduced chiefly from observations covering the winter months. For the summer months the distribution of pressure changes. The high over the northeast portion of the Pacific Ocean causes brisk to high northwest winds along our Pacific coast. It is not known just what effect its displacement to the north would have; but the present summer seems to afford an interesting opportunity for study in this direction. This summer has been practically a rainless one in our North Pacific States. At the time of writing (August 11, 1910), there has been no rain at Portland, Oreg., for fifty days. This is said to be one of the longest dry spells on record. A similar condition occurred in 1896 (fifty-one days without rain) and again in 1875. If this dry condition is connected with the displacement of the North Pacific high, there should also be an [compensating] abnormal condition on the Asiatic side. There are press reports of unusually heavy rains on the Japanese coast.

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(XIV) ON PASSING THROUGH THE TAIL OF HALLEY'S COMET.

By W. J. Humphreys. (Dated October 25, 1910.)

Because so little is known about comets it was both natural and proper that particular attention should be given to that great historic one, known as Halley's, during its recent near approach to the earth; and especially so since it was expected to transit the sun, and the earth to pass through its tail at no great astronomical distance from the head.

Careful preparations were made for the study of this comet, not because disastrous or even spectacular phenomena were anticipated, but simply to note any minute effects, of whatever nature, that might be attributable to the comet itself, or to our passage through its tail, and in this way to add something to our scanty knowledge of the nature, origin and destiny of these strange celestial objects.

So far as the scientific world is concerned it may at once be said that nothing more than very slight terrestrial disturbances of any kind were expected, and that instead of being surprised at the magnitude of the results it does not feel certain that even any effect at all was observed; certainly no magnetic nor electric phenomena were noted that appear necessarily or even reasonably attributable to any portion or action of the comet.

The head of the comet seems to have been invisible as it passed across the face of the sun, and hence we can say, as other observations had indicated, that the solid nucleus, if there is one, is small—not more than a few miles in diameter. Thus a rough upper limit to the size of anything like an opaque or solid head is set by these transit observations, though what the other, or lower, limit may be no one knows.

Particular attention, of course, was given to certain magnetic, electric, and meteorological phenomena that conceivably might depend upon or be modified by the passage of the earth through the substance of a comet's tail.

Many of these phenomena and the possible influence of the comet's tail upon them were briefly referred to in the technical journals by the author and others with the hope of enlisting the assistance of numerous and widely-scattered observers. In addition to this, and to be certain of securing trustworthy meteorological observations, the Chief of the United States Weather Bureau, Prof. Willis L. Moore, wisely sent out a circular letter to nearly two hundred meteorological stations in the

United States and the West Indies, asking that on the 17th, 18th especially, and 19th of May particular observations be taken, the nature and purpose of which are made clear by the following copy of this letter itself:

U. S. Department of Agriculture,
Central Office of the Weather Bureau,
Washington, D. C., March 21, 1910.

CIRCULAR LETTER.

METEOROLOGICAL OBSERVATIONS TO BE MADE ON THE 17TH, 18TH ESPECIALLY, AND 19TH OF MAY, 1910.

If the earth should pass through the tail of Halley's comet, as astronomers expect it will on the 18th of May next, an opportunity of a kind that has not previously occurred in the history of the Weather Bureau will be offered for the study of certain meteorological phenomena. It has been decided to take advantage of this opportunity and you will please aid in securing the necessary observations, as far as weather conditions and your regular duties will permit. The suggestion is made that other persons may be found who are sufficiently interested in the subject to cooperate with you in this work.

Owing to the position of the moon on the given dates it is probable that the most satisfactory night observations will be obtained during the last two or three hours before daylight.

Please observe as many of the following phenomena as you understand and feel capable of handling.

1. *Auroral displays.*—Auroras serve as indicators of the electrical state of the outer atmosphere, and as this state possibly may be affected by the tail of the comet as we pass through it, auroras should be watched for at that time. The location, color, shape, extent, and other features as well as the times of appearance, changes, and disappearance should all be carefully noted.

2. *Meteoric trails.*—The number, times of appearance, lengths of duration, and directions and lengths of visible paths of meteors should be noted on all three nights, but especially on the night of the 18th.

3. *Bishop's ring.*—This curious "dust" halo was seen around the sun after the eruptions both of Krakatoa and Mont Pelé, and conceivably might also follow the passage of the earth through the tail of a comet. It therefore should be carefully looked for on the days specified, and, occasionally, for some days thereafter.

As the light of this ring is rather faint, observations of it are best made when the sun is hidden behind some steeple or other opaque object.

4. *Color of the sun and sky.*—Both the general color of the sky and the color of the sun depend on the dust and other contents of the atmosphere, and should be carefully noted on the given dates.

5. *Twilight phenomena.*—Twilight colors, their distribution, and order of changes depend largely on the dust in the atmosphere, and, consequently, these are phenomena that need to be observed on the days indicated.

6. *Luminous clouds.*—Neither the material of these clouds nor the cause of their light is definitely known. They seem to belong to the very high atmosphere, and therefore should be looked for at night in connection with our transit across the comet's tail.

These clouds are cirrus-like in appearance, but may be distinguished from true cirrus by the fact that they are brighter than the background of the clear nocturnal sky. During the fore part of the night they are seen above the northwestern horizon.

7. *Zodiacal light.*—From work recently done at the Lick and at the Mount Wilson observatories it seems probable that the zodiacal light is caused by the reflection of solar light from dust in and near the plane of the ecliptic. If so, then a change might be expected in it at the time of the comet's near approach to the earth, and therefore the extent, brilliancy, and other features of the zodiacal light as they appear at that time should be carefully noted.

8. *Gegenschein* (counter glow).—But little is known of the cause of this faint glow seen in the ecliptic at a point directly opposite to the sun, or along the shadow of the earth. Presumably it has the same origin as the zodiacal light, and consequently may be modified during the transit of the earth across the tail of a comet. At any rate it should be observed on the nights mentioned, and its brilliancy at these times compared with that on nights when there certainly is no cometary disturbance.

To locate the gegenschein at any hour of the night look in the direction where the sun was twelve hours previously.

9. *General phenomena.*—Solar and lunar halos and coronas, and all other appearances that may seem unusual and worth noting.

A full and prompt report to the Central Office will be expected of all observations made.

WILLIS L. MOORE,
Chief U. S. Weather Bureau.

At the time this letter was prepared it was known that the transit of the comet across the disk of the sun would take place almost certainly some time on the 18th, and, therefore, that the earth could not enter the tail before that date. Nevertheless it seemed advisable for the observations to begin at least one day ahead of time for the purpose of securing records of undisturbed conditions of about the same date with which to compare those obtained while the earth was actually in the tail.

Careful observations were taken during the given three days and nights at all stations to which the above circular letter was sent, and prompt reports were made to the Central Office of the phenomena seen. A number of reports were also received from voluntary observers, and all have been put on file.

As an illustration of the care with which the observations were taken, the following brief report from Mount Weather, Va., is given in full:

U. S. DEPARTMENT OF AGRICULTURE,
RESEARCH OBSERVATORY OF THE WEATHER BUREAU,
Mount Weather, Va., May 20, 1910.

Prof. ALFRED J. HENRY,
Executive Officer in Charge.

In compliance with the circular letter of March 21, I have the honor to report the following recent observations on the phenomena attending Halley's comet:

1. No auroral phenomena were seen from May 16, p. m., to May 20, a. m.; the sky was sufficiently clear in the evenings of the 16th, 17th, and 18th, but not the 19th.

2. No meteors or meteoric flashes were seen.

3. No Bishop's ring nor even small glories close to the sun during the daytime.

4. No special colors in the daylight sky, which was a very pure blue or blue-black, on the 17th and 18th and up to 4 p. m. of the 19th, when low cirri began to come over from the west.

5. At sunset of the 18th and sunrise of the 19th there were no unusual colors. At the horizon the sun was a deep cherry red, due to the low haze and dust which stopped abruptly at 3° altitude. Above this layer up to the zenith the blue skylight was polarized approximately normally, as shown by a single Nicol prism, but I had no polarimeter for exact measures.

6. There were no noctiluminous clouds at 11 p. m. of the 18th, nor at 3 a. m. of the 19th. In the morning of Tuesday, the 17th, there was a fine view of the comet's tail up to 3:13 a. m., but it began to shrink at 3:15 in the twilight. Its length, 60°, and breadth, 3°, varied, increasing and diminishing as twilight progressed until it disappeared at 3:30 a. m. The tail was as bright as the Milky Way, and was nearly perpendicular to it. There was also a streak of haze from northwest to southeast, but no other clouds, and this one streak disappeared by 3:20 a. m. On the morning of Thursday, the 19th, from 3:35 to 3:50 a. m., the sky being quite clear, there was a faint streak like the comet's tail stretching from the east, or perhaps 5° north of east, up to the zenith, but soon fading away in the twilight. As the nucleus of the comet had presumably passed the sun at 10 or 11 p. m. the previous night, this tail was taken to be possibly a remnant that had separated from the nucleus and had not yet entirely faded out. At 4:30 a. m. of the 19th the zenithal sky was very largely polarized. The sun's center was in the horizon at 4:52 a. m., eastern time.

7. The zodiacal light was not seen after the clear sunsets of the 16th, 17th, and 18th, nor before sunrise in the mornings, but it had been well seen during several evenings in April and May.

8. No gegenschein was observed, but I could not look for it at those hours of the night when it is best seen.

9. No solar nor lunar halos were seen, although carefully looked for up to noon of the 19th.

Respectfully,

(Signed) CLEVELAND ABBE.

It would be interesting and possibly of some use to print all of the reports in full, but as this is impracticable, the following table of possibly positive results made up from them is given for the convenience of those who may have need for this information. It distinctly is not claimed that any of the phenomena referred to in this table were certainly due to the comet. They are given because at present the possibility of the comet's influence in producing them can not definitely be excluded. This table is restricted to observations made on the 19th of May, because but little was seen on either the 17th or 18th, and also because, if the earth passed through any portion of the comet's tail at all, it probably did so on the 19th.

Phenomena, possibly due in part to Halley's Comet, observed by Weather Bureau officials on the 19th of May, 1910.

Place.	Observer.	Hour.	Phenomena.
Macon, Ga	W. A. Mitchell	Much of the day. Most marked at 10 a. m.	Formless, motionless, pale-yellow haze over a zone 40° wide along the ecliptic.
Springfield, Mo	J. S. Hazen	Forenoon	Solar halo.
Chicago, Ill	H. J. Cox	11:45 a. m. to 12:15 p. m.	Double solar halo 45° and 90° diameter.
Lexington, Ky	G. H. Noyes		Brilliant solar halo.
Grand Haven, Mich	C. H. Eshleman	11 to 11:30 a. m.	Solar halo, colors diffused through the circle.
Grand Haven, Mich	C. H. Eshleman	6:10 p. m.	Parhelia.
Lansing, Mich	D. A. Seeley	Afternoon	Bright solar halo.
Reno, Nev	H. F. Alps	11:05 a. m. to noon.	Solar halo.
Moorestown, N. J	J. C. Beans	9:30 a. m.; 11:00 a. m.; noon.	Solar halo.
Moorestown, N. J	J. C. Beans	11:15 p. m.	Lunar halo.
Asheville, N. C	R. T. Lindley	8:45 a. m.	Solar halo, 45° diameter, vivid coloring.
Charlotte, N. C	W. V. Martin	10 to 11:30 a. m.	Solar halo, 45° diameter, remarkably distinct and brilliant; rainbow colors easily distinguished. Light cirrus clouds near horizon, but none could be seen elsewhere.
Charlotte, N. C	W. V. Martin	Early p. m.	Solar halo in upper clouds that gathered rapidly.
Waynesville, N. C	Dr. G. B. Green	Noon	Solar halo, colored. Sky dark inside, clear outside.
Cincinnati, Ohio	M. E. Blystone	10:40 a. m.	Solar halo.
Grants Pass, Oreg	J. B. Paddock	All day	Solar halo.
Roseburg, Oreg	W. Bell	All day	Solar halo.
Roseburg, Oreg	W. Bell	4:30 p. m.	Two parhelia with rainbow colors.
Scranton, Pa	W. M. Dudley	Sundown	Unusually brilliant sunset. Sun deepest blood red.
Abilene, Tex	W. H. Green	10 to 10:15 a. m.	Solar halo.
Trinidad, Wash	J. C. Wheeler	11 a. m. to 1 p. m.	Most pronounced halo ever seen.
Basseterre, St. Kitts, W. I.	D. H. Ross	10:40 a. m. to 1:45 p. m.	Solar halo, at times exceedingly bright.

Similar phenomena have been reported from other places. Prof. E. B. Frost, Director of the Yerkes Observatory, states that from noon till about 1 p. m. of the 19th there were seen from that observatory a solar halo of 22° radius and at the same time a number of irridescent clouds of unusual brilliancy, one of which had the general appearance of a long nearly straight rainbow.

Prof. Max Wolf reports from the Königstuhl Observatory[1] that late in the afternoon of the 19th a Bishop's ring was seen around the sun, and that this was followed by a twilight of unexpected intensity, extension, and duration; that three twilight purple glows succeeded each other, and that all the particular sky phenomena following the eruptions of Krakatoa and Mont Pelé appeared in an intensified manner. Also that a Bishop's ring more intense than any he had ever seen before, and of 28° outer radius, indicating particles of 1.5μ diameter, appeared about the moon.

In the same number, 4414, of the Astronomische Nachrichten, W. Krebs, reports from Grossflottbek that from 4 to 4:30 p. m. a parhe-

[1]Astronomische Nachrichten, No. 4414.

lion was seen, and that at the same time a peculiar shimmering white corona of 5° radius appeared around the sun.

It is reported by Émile Marchand[2] that observations made on Pic du Midi and at Bagnères-de-Bigorre showed, on the morning of the 20th, a lunar corona and a bright tinted sky such as was seen after the eruption of Mont Pelé. These phenomena were even more pronounced on the evening of the 20th. There was also an analogous solar corona of 3° to 4° diameter on the 20th, that was still seen on the 2d of June.

The halos, coronas, and other phenomena listed above were both widely scattered and, in some respects, distinctly unusual; and their occurrence coincident, as nearly as can be determined, with the passage of the earth through the tail (or at least its extension) of the comet suggests for them a cosmical origin. Still they certainly were far from universal, and besides they have all been seen before when there was no comet to which they could be attributed; and, therefore, while admitting the possibility, in this case, of a cometary influence, it would seem rash, without additional evidence, to conclude that the comet was the principal or even partial cause of any of the appearances mentioned above.

[2] Paris, C. R. 150, 1404; 1575.

(XV) FREE AIR DATA AT MOUNT WEATHER FOR JULY, AUGUST, AND SEPTEMBER, 1910.

By the Aerial Section—WM. R. BLAIR in charge.

In the 92 days of this period, 92 ascensions were made, 66 with kites and 26 with captive balloons. The highest altitudes reached with the kites average 2477 meters above sea level, with the balloons, 2484. The highest kite flight of the period was 4562 meters above sea level, the highest captive balloon ascension, 3227.

The prevailing wind for July was decidedly west, that for August decidedly southeast, for September, northwest, though southeast winds were nearly as frequent. The mean wind velocity for the period is 5.5 meters per second, the July mean being 5.6 and the August 5.4. These velocities are greater than those for the same period of either of the past two years, but the winds seemed shallower. The mean of the highest altitudes reached in the kite flights is consequently less than in the past two years.

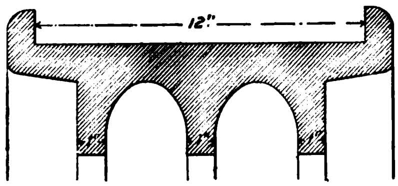


FIG. 7.—Partial cross-section of new barrel for kite reel drum.

The conditions for very high kite flights were not often favorable during these three months and when they were, the kite flying apparatus was not in order to take advantage of them. The flange of the barrel for the kite reel drum described in Vol. II, Part 4, page 237, stripped off and necessitated the use of a weaker drum during most of the period. It is thought that the middle reinforcement of the broken drum (see fig. 1, above reference) buckled, at the same time those on either side spread. The circumference of the drum became less just over the middle reinforcement, thus throwing undue strain on the flanges. A new casting has recently been installed, made from the pattern previously used, except that the inside reinforcements of the barrel are further supported by filling as shown in fig. 7, and the width of the flanges is increased from ½ to 1 inch. The purpose of these changes is to prevent buckling of the reinforcements and flanges.

The pressure changes for the period, as shown by the station barogram, are small and the curve smooth. The daily changes in temperature are therefore the most prominent feature in Charts XIII to XVIII, inclusive, the irregularities in the isotherms being mostly due to temperatures peculiar to the vicinity of the cloud and fog layers.

Figs. 8, 9, and 10 show the mean hourly temperatures at the mountain and valley surface stations for the three months. In fig. 10, the Audley temperatures are not for the complete month, the curve representing mean hourly temperatures for September 1 to 24, inclusive. The record of cloudiness at Mount Weather follows:

Month.	Number of days.			Mean cloudiness.
	Clear.	Partly cloudy.	Cloudy.	
July	13	11	7	4.5
August	11	13	7	5.4
September	10	13	7	5.0

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
July 1.	mm.	°C.	%		m. p. s.	m.	mm.	°C.	%		m. p. s.
3:30 p. m....	713.9	32.0	49	s.	3.1	526	713.9	32.0	49	s.	3.1
3:43 p. m....	713.9	32.2	47	s.	2.2	1928	609.3	19.6	......	nw.	....
4:04 p. m....	713.9	31.6	47	s.	2.7	1406	646.5	22.2	......	wnw.	....
4:16 p. m....	713.9	31.2	47	s.	2.7	1255	657.6	23.8	......	w.	....
4:26 p. m....	713.9	30.8	49	s.	2.7	904	684.3	27.0	......	sw.	....
4:32 p. m....	713.9	30.6	49	s.	2.2	526	713.9	30.6	49	s.	2.2
July 2.											
6:32 a. m....	714.1	22.8	71	wnw.	4.9	526	714.1	22.8	71	wnw.	4.9
6:43 a. m....	714.1	22.2	76	wnw.	4.9	790	693.0	24.8	......	nw.	....
6:59 a. m....	714.1	21.6	81	wnw.	4.5	1031	674.2	26.1	......	nw.	....
7:33 a. m....	714.2	21.0	86	wnw.	8.9	1473	641.2	22.1	......	nw.	....
9:11 a. m....	714.2	22.5	82	wnw.	5.8	2129	594.5	16.4	......	wsw.	....
9:32 a. m....	714.2	22.6	81	wnw.	11.6	1270	656.2	23.7	......	wnw.	....
9:40 a. m....	714.2	22.6	82	wnw.	11.6	962	679.5	25.7	......	nw.	....
9:51 a. m....	714.2	23.0	79	wnw.	11.6	791	693.0	23.8	......	nw.	....
9:55 a. m....	714.2	23.0	78	wnw.	11.2	526	714.2	23.0	78	wnw.	11.2
July 3.											
6:27 a. m....	713.5	22.7	86	nw.	8:9	526	713.5	22.7	86	nw.	8.9
6:37 a. m....	713.5	22.7	86	nw.	8.9	821	689.8	22.2	......	nw.	....
7:53 a. m....	713.5	22.7	88	nw.	8.0	1040	672.7	24.0	......	nw.	....
8:02 a. m....	713.5	22.6	89	nw.	8.0	1327	650.9	21.6	......	nw.	....
8:30 a. m....	713.5	22.4	90	nw.	8.9	926	676.1	24.6	......	nw.	....
8:53 a. m....	713.5	22.6	90	wnw.	9.8	821	689.8	21.9	......	nw.	....
8:58 a. m....	713.5	22.5	90	wnw.	10.3	526	713.5	22.5	90	wnw.	10.3

July 1.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2438 m.
Sky cloudless. Light haze.
Pressure was high over West Virginia and low over Nova Scotia and Louisiana.

July 2.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 6000 m.; at maximum altitude, 2500 m.
There was dense haze.
Areas of low pressure were central over Arkansas, Lake Superior, and the lower St. Lawrence. A high was central over Florida.

July 3.—Six kites were used; lifting surface, 38.8 sq. m. Wire out, 5100 m., at maximum altitude.
There was dense haze until the end of the flight, when 7/10 A.-Cu., from the west-southwest, were seen.
A trough of low pressure extended from the St. Lawrence to Arkansas. Centers of high pressure lay over Florida and Manitoba.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
July 4.	mm.	° C.	%		m. p. s.	m.	mm.	° C.	%		m. p. s.
6:27 a. m....	712.5	19.8	96	wnw.	9.8	526	712.5	19.8	96	wnw.	9.8
6:35 a. m....	712.5	19.9	95	wnw.	9.8	804	690.0	19.8	......	nw.	....
6:46 a. m....	712.6	19.8	95	wnw.	9.8	1182	660.4	17.6	......	nw.	....
7:19 a. m....	712.6	19.8	96	wnw.	10.7	1664	624.3	16.7	......	nw.	....
8:08 a. m....	712.7	20.5	95	wnw.	11.2	2026	598.5	11.9	......	nw.	....
8:42 a. m....	712.9	20.7	95	wnw.	7.6	2620	557.6	9.5	......	nw.	....
8:51 a. m....	713.0	21.4	93	wnw.	6.7	2968	534.4	7.2	......	nw.	....
9:01 a. m....	713.0	21.9	91	wnw.	6.3	2651	554.9	8.8	......	nw.	....
9:15 a. m....	713.0	22.1	90	wnw.	6.3	1984	601.0	13.0	......	nw.	....
9:26 a. m....	713.1	21.7	92	wnw.	5.8	1554	631.9	15.3	......	nw.	....
9:35 a. m....	713.1	21.9	94	wnw.	4.9	1160	662.4	15.7	......	nw.	....
9:48 a. m....	713.2	22.7	89	wnw.	5.4	771	693.4	18.8	......	nw.	....
9:55 a. m....	713.2	23.1	91	wnw.	5.4	526	713.2	23.1	91	wnw.	5.4
July 5.											
6:18 a. m....	718.6	17.0	69	e.	5.4	526	718.6	17.0	69	e.	5.4
6:32 a. m....	718.7	17.0	69	e.	5.4	794	696.5	14.8	......	e.	....
6:42 a. m....	718.7	16.8	71	e.	5.4	1002	679.6	14.8	......	e.	....
8:10 a. m....	719.4	17.8	72	e.	6.7	1348	652.9	11.7	......	e.	....
8:25 a. m....	719.4	17.9	73	e.	4.5	1011	679.6	13.7	......	e.	....
8:35 a. m....	719.5	17.9	73	e.	4.9	526	719.5	17.9	73	e.	4.9
July 6.											
1:19 p. m....	718.4	22.4	57	sse.	6.3	526	718.4	22.4	57	sse.	6.3
1:29 p. m....	718.4	22.2	58	se.	8.0	804	695.8	18.4	......	sse.	....
2:51 p. m....	718.0	20.0	74	sse.	5.8	1374	650.1	13.3	......	s.	....
3:07 p. m....	718.0	20.6	71	sse.	5.8	797	695.8	17.1	......	sse.	....
3:17 p. m....	717.9	20.6	73	sse.	6.7	526	717.9	17.4	73	sse.	6.7

July 4.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 6550 m.; at maximum altitude, 5000 m.

St.-Cu., from the northwest, diminished from 10/10 at the beginning of the flight to 5/10 at 7:30 a. m. and increased to 9/10 by 9 a. m. The altitude of their base was about 1200 m. at 9:30 a. m. About 3/10 Ci.-Cu. from the west were also visible between 7 and 8 a. m.

At 8 a. m. pressure was high over the upper Lakes and low off the New England States and over the lower Mississippi Valley.

July 5.—Five kites were used; lifting surface, 32.5 sq. m. Wire out, 3800 m.; at maximum altitude, 3500 m.

There were about 8/10 Ci.-St. and Ci.-Cu. from the west.

At 8 a. m. pressure was generally relatively high over the eastern part of the country.

July 6.—Four kites were used; lifting surface, 30.6 sq. m. Wire out, 2800 m.; at maximum altitude, 1200 m.

At the beginning there were 4/10 Ci. from the northwest and 2/10 St.-Cu. from the west. After 2:51 p. m there were 10/10 St.-Cu. from the west.

Low pressure was central north of Lake Superior and pressure was relatively high along the Atlantic coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. July 7.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
8:49 a. m....	713.3	18.5	100	se.	6.7	526	713.3	18.5	100	se.	6.7
1:24 p. m....	712.3	20.8	98	s.	4.0	772	692.4	21.2	......	s.	....
2:09 p. m....	711.9	21.0	96	s.	4.0	1237	655.6	17.1	......	sw.	....
2:16 p. m....	711.9	21.0	96	s.	4.0	2024	597.5	11.9	......	wsw.	....
3:10 p. m....	711.4	21.3	96	sw.	4.5	1694	621.0	15.1	......	wsw.	....
3:41 p. m....	711.2	21.5	96	sw.	4.5	1229	655.6	18.3	......	sw.	....
4:12 p. m....	711.0	21.6	96	sw.	4.5	948	677.2	19.9	......	sw.	....
4:38 p. m....	711.0	22.0	97	wsw.	4.5	1611	626.9	15.7	......	w.	....
4:54 p. m....	711.0	22.3	92	wsw.	4.5	1088	666.5	20.3	......	w.	....
5:03 p. m....	711.0	22.6	86	wsw.	4.5	777	690.7	21.4	......	w.	....
5:07 p. m....	711.0	22.7	87	wsw.	4.0	526	711.0	21.7	87	wsw.	4.0
July 8.											
8:15 a. m....	713.8	21.0	86	nw.	8.9	526	713.8	21.0	86	nw.	8.9
8:24 a. m....	713.8	21.3	88	nw.	8.9	873	685.9	21.0	......	nw.	....
9:23 a. m....	713.9	22.3	86	nw.	9.8	1049	672.2	22.9	......	nw.	....
9:50 a. m....	714.0	22.8	86	nw.	6.7	1168	663.4	20.0	......	nw.	....
10:00 a. m....	714.0	23.0	82	nw.	6.3	1617	629.5	17.8	......	nw.	....
10:18 a. m....	714.0	23.9	80	nw.	5.4	1258	656.3	20.8	......	nw.	....
10:23 a. m....	714.0	24.0	80	nw.	5.4	1074	670.5	21.5	......	nw.	....
10:28 a. m....	714.0	24.0	79	nw.	5.8	833	689.3	20.6	......	nw.	....
10:38 a. m....	714.0	24.0	77	nw.	5.8	754	714.0	24.0	77	nw.	5.8
July 9.											
1:14 p. m....	716.0	28.3	60	wnw.	1.8	526	716.0	28.3	60	wnw.	1.8
1:28 p. m....	715.9	28.2	59	wnw.	2.2	2428	574.6	13.3	......	wsw.	....
1:38 p. m....	715.9	28.6	58	w.	2.2	1761	621.6	16.8	......	wsw.	....
1:54 p. m....	715.7	29.0	58	sw.	1.8	1392	648.6	20.1	......	wsw.	....
2:06 p. m....	715.7	29.4	59	wsw.	1.8	986	679.6	24.3	......	wsw.	....
2:13 p. m....	715.7	29.6	57	wsw.	1.8	526	715.7	29.6	57	wsw.	1.8
July 10.											
6:15 a. m....	716.4	22.3	86	w.	6.7	526	716.4	22.3	86	w.	6.7
7:26 a. m....	716.5	23.0	85	wnw.	6.7	931	684.2	23.8	......	nw.	....
8:22 a. m....	716.5	24.5	81	wnw.	6.7	1200	663.3	20.6	......	nw.	....
9:28 a. m....	716.4	25.4	77	wnw.	5.4	867	689.2	23.9	......	nw.	....
9:40 a. m....	716.3	26.0	71	wnw.	5.4	526	716.3	26.0	71	wnw.	5.4

July 7.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 3100 m.; at maximum altitude, 2550 m.

There was dense fog until 10:41 a. m. and light fog until 11:22. There were 10/10 St. from the south until 1:25 p. m. and 8/10 to 10/10 St. from the south and St.-Cu. from the west thereafter. Rain fell at intervals after 9:34 a. m.

Pressure was low over Ontario and high over Florida.

July 8.—Seven kites were used; lifting surface, 45.1 sq. m. Wire out, 4500 m.; at maximum altitude, 3900 m.

There were a few to 2/10 A.-St. from the west-northwest during the flight.

Areas of low pressure were central over the lower St. Lawrence and north of Lake Superior. High pressure was central over Florida.

July 9.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2600 m.

There were 6/10 Cu. from the west-southwest at an altitude of about 1600 m.

At 8 a. m. pressure was relatively high off the south Atlantic coast and low north of the Lake region.

July 10.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 3675 m.; at maximum altitude, 3250 m.

There were 5/10 to 1/10 A.-St. from the west-southwest.

Low pressure was central over Ontario. Areas of high pressure were central off the Georgia coast and over Nebraska.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910.											
July 11.	*mm.*	*° C.*	*%*		*m. p. s.*	*m.*	*mm.*	*° C.*	*%*		*m. p. s.*
6:55 a. m....	717.4	21.4	86	nw.	13.4	526	717.4	21.4	86	nw.	13.4
7:02 a. m....	717.4	21.7	84	nw.	12.5	842	691.8	19.7	......	nw.	....
7:15 a. m....	717.6	22.0	84	nw.	13.0	1315	655.0	18.3	......	nw.	....
7:36 a. m....	717.9	22.3	82	nw.	12.5	1446	645.6	19.8	......	nw.	....
7:48 a. m....	718.2	22.6	82	nw.	13.0	1770	622.1	18.1	......	nw.	....
8:01 a. m....	718.4	22.8	82	nw.	12.1	2180	5[illegible]3.1	15.0	......	nw.	....
8:26 a. m....	718.9	22.8	81	nw.	10.7	2619	563.3	10.1	......	nw.	....
9:02 a. m....	719.4	23.6	77	nw.	7.2	2270	587.0	13.0	......	nw.	....
9:50 a. m....	719.9	24.3	76	nw.	4.5	2000	606.5	14.5	......	nw.	....
10:03 a. m....	720.0	24.4	77	nw.	4.5	1809	620.3	16.3	......	nw.	....
10:16 a. m....	720.1	24.7	77	nw.	4.5	1471	645.6	15.4	......	nw.	....
10:31 a. m....	720.2	25.0	75	nw.	3.1	526	720.2	25.0	75	nw.	3.1
July 12.											
7:36 a. m....	720.0	22.4	94	sse.	5.4	526	720.0	22.4	94	sse.	5.4
8:00 a. m....	720.0	23.1	87	s.	4.5	749	702.0	24.3	......	s.	....
8:44 a. m....	719.9	23.4	89	se.	4.9	1055	677.8	22.1	......	ssw.	....
10:20 a. m....	719.8	25.1	83	sse.	4.9	1611	635.6	18.7	......	sw.	....
10:57 a. m....	719.7	25.4	80	sse.	4.9	2070	602.3	15.8	......	sw.	....
11:05 a. m....	719.7	25.7	78	se.	4.9	1742	626.0	18.1	......	sw.	....
11:24 a. m....	719.6	26.4	78	sse.	4.9	1323	657.0	20.5	......	sw.	....
11:35 a. m....	719.6	26.5	78	se.	5.4	808	697.0	23.2	......	s.	....
11:40 a. m....	719.6	26.4	77	se.	5.4	526	719.6	26.4	77	se.	5.4
July 13.											
7:08 a. m....	717.2	21.8	81	w.	8.5	526	717.2	21.8	81	w.	8.5
7:19 a. m....	717.2	21.8	81	w.	8.9	892	687.7	20.2	......	wnw.	....
7:29 a. m....	717.2	21.7	82	wnw.	8.9	1344	652.6	19.4	......	wnw.	....
7:45 a. m....	717.3	21.5	86	wnw.	8.9	1790	619.6	17.4	......	wnw.	....
7:57 a. m....	717.3	21.6	87	wnw.	10.7	2293	584.4	15.8	......	wnw.	....
8:41 a. m....	717.5	22.3	84	wnw.	9.8	3197	524.4	9.1	......	w.	....
9:34 a. m....	717.9	22.5	87	wnw.	6.7	4151	465.9	0.8	......	w.	....
10:20 a. m....	718.1	23.6	78	wnw.	8.0	3440	509.4	6.8	......	w.	....
10:51 a. m....	718.2	24.4	73	wnw.	4.5	2955	540.3	9.2	......	w.	....
11:16 a. m....	718.2	24.2	73	wnw.	8.5	2467	572.6	12.3	......	wnw.	....
11:20 a. m....	718.2	24.2	73	wnw.	8.5	2297	584.4	11.5	......	wnw.	....
11:31 a. m....	718.3	23.8	74	wnw.	9.4	1965	607.7	12.8	......	wnw.	....
11:47 a. m....	718.3	23.6	77	wnw.	8.0	1235	661.8	16.6	......	wnw.	....
12:00 m......	718.3	23.6	79	wnw.	6.3	884	689.4	19.8	......	wnw.	....
12:07 p. m....	718.3	23.6	79	wnw.	5.8	526	718.3	23.6	79	wnw.	5.8

July 11.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 7200 m.; at maximum altitude, 5200 m.

There were 3/10 to 4/10 St.-Cu. from the northwest.

The head kite was in the clouds at intervals from 8:03 to 10:09 a. m.

Pressure was high over the Ohio Valley and south Atlantic coast States and low over the Gulf of St. Lawrence.

July 12.—Five kites were used; lifting surface, 37.4 sq. m. Wire out, 2500 m.; at maximum altitude, 2400 m.

At the beginning there were 3/10 A.-Cu. from the southwest, 1/10 St.-Cu. from the west-southwest, and 1/10 St. from the south-southeast. The A.-Cu. moved from the west-southwest after 8:45, and from the west after 10 a. m. At the end there was 1/10 Cu. from the southwest.

Pressure was low over the Lake region and high off the south Atlantic coast.

July 13.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 7500 m.; at maximum altitude, 6900 m.

There were 8/10 A.-St. from the west-southwest until 8:30 a. m. and 5/10 A.-St. and 4/10 St.-Cu. from the west thereafter.

An area of low pressure was central over the lower St. Lawrence. Pressure was high over the upper Mississippi Valley and the Southern States.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
July 14.	*mm.*	*° C.*	*%*		*m. p. s.*	*m.*	*mm.*	*° C.*	*%*		*m. p. s.*
1:39 p. m....	719.6	23.0	55	e.	2.7	526	719.6	23.0	55	e.	2.7
1:57 p. m....	719.4	23.2	58	se.	2.2	2928	542.6	10.3	......	w.	....
2:01 p. m....	719.4	23.4	55	ese.	2.2	2774	552.8	10.3	......	w.	....
2:15 p. m....	719.3	23.4	58	ese.	2.2	2189	592.8	12.9	......	calm.	....
2:26 p. m....	719.1	23.7	59	ese.	3.1	1540	639.6	16.9	......	calm.	....
2:33 p. m....	719.0	23.1	59	ese.	3.6	887	689.8	20.2	......	se.	....
2:44 p. m....	718.8	22.8	59	ese.	4.0	526	718.8	22.8	59	ese.	4.0
July 15.											
1:09 p. m....	715.9	27.0	64	nw.	3.6	526	715.9	27.0	64	nw.	3.6
1:20 p. m....	715.8	26.7	64	nw.	5.4	1129	668.3	20.5	......	nw.	....
1:27 p. m....	715.8	26.7	64	nw.	4.9	845	690.5	23.3	......	nw.	....
1:53 p. m....	715.6	26.8	63	nnw.	4.5	526	715.6	26.8	63	nnw.	4.5
July 16.											
6:27 a. m....	713.8	21.4	84	w.	6.3	526	713.8	21.4	84	w.	6.3
7:16 a. m....	713.7	21.9	84	wnw.	6.3	763	694.7	23.9	......	wnw.	....
7:36 a. m....	713.5	22.1	82	wnw.	7.6	1301	652.8	20.0	......	w.	....
8:47 a. m....	712.9	23.0	80	wnw.	7.2	1957	604.2	14.5	......	wsw.	....
10:20 a. m....	712.7	24.8	75	wnw.	6.7	2458	569.2	11.5	......	wsw.	....
10:29 a. m....	712.7	24.4	76	nw.	7.2	1818	613.9	16.7	......	w.	....
10:42 a. m....	712.7	25.0	75	wnw.	8.0	1266	654.5	19.8	......	wnw.	....
10:52 a. m....	712.7	25.5	74	wnw.	4.5	1147	663.7	19.2	......	nw.	....
10:59 a. m....	712.7	25.4	74	nw.	5.4	921	681.2	20.6	......	nw.	....
11:08 a. m....	712.7	24.8	74	wnw.	4.9	526	712.7	24.8	74	wnw.	4.9
July 17.											
6:33 a. m....	709.4	19.9	90	w.	7.6	526	709.4	19.9	90	w.	7.6
6:42 a. m....	709.4	19.8	91	w.	6.3	893	679.9	19.6	......	nw.	....
6:50 a. m....	709.5	19.7	94	wnw.	6.7	1118	662.4	17.0	......	nw.	....
7:21 a. m....	709.5	19.7	96	nw.	8.9	1189	657.0	23.5	......	nw.	....
7:40 a. m....	709.5	20.0	94	nw.	4.9	1960	601.1	17.5	......	nnw.	....
7:50 a. m....	709.5	20.1	94	nw.	3.6	1707	618.5	20.1	......	nnw.	....
8:02 a. m....	709.5	20.5	92	nnw.	3.1	1259	651.5	16.8	......	nnw.	....
8:10 a. m....	709.5	20.4	93	nnw.	3.1	526	709.5	20.4	93	nnw.	3.1

July 14.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2600 m.

There were 6/10 to 8/10 St.-Cu. from the west, the altitude of their base being about 2800 m.

At 8 a. m. pressure was moderately high over the Eastern States.

July 15.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2200 m.

There were 9/10 Ci.-Cu. and a few Cu. from the west.

Pressure was low over the Gulf of St. Lawrence and Kansas and high over Florida.

July 16.—Eight kites were used; lifting surface, 51.4 sq. m. Wire out, 5000 m.; at maximum altitude, 3400 m.

There were 8/10 to 4/10 Ci.-St. from the northwest, St.-Cu. from the west-southwest, and A.-Cu. and Cu. from the west-northwest.

Pressure was low over New Brunswick, Lake Erie, and the lower Ohio Valley; and was high over the Gulf coast.

July 17.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 2700 m., at maximum altitude.

There were 8/10 clouds consisting of Ci. from the west and St.-Cu. from the northwest until 7:14 a. m. and from 4/10 to 9/10 clouds thereafter consisting of St. Cu. from the northwest and St. from the northwest which changed to north-northwest by 7:47 a. m. The St. were at an altitude of 1200 m.

Pressure was low over Virginia and high over northwest Ontario.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
July 18.	*mm.*	*°C.*	*%*		*m. p. s.*	*m.*	*mm.*	*°C.*	*%*		*m. p. s.*
7:27 a. m....	713.7	14.5	70	e.	4.9	526	713.7	14.5	70	e.	4.9
7:35 a. m....	713.7	14.2	74	ese.	4.5	939	679.6	11.6	......	ene.	....
7:53 a. m....	713.7	14.4	73	e.	5.8	1596	628.1	7.9	......	ne.	....
8:11 a. m....	713.8	14.6	71	e.	5.8	2215	583.0	9.0	......	ne.	....
9:17 a. m....	714.4	15.8	74	n.	2.2	2514	563.1	7.7	......	ne.	....
9:45 a. m....	714.6	16.6	69	ene.	5.4	1977	600.8	9.0	......	ne.	....
9:49 a. m....	714.6	17.0	69	ene.	5.4	1822	612.3	8.1	......	ne.	....
10:00 a. m....	714.7	16.8	69	ne.	4.9	1461	639.6	8.9	......	ne.	....
10:16 a. m....	714.7	16.9	70	ne.	5.4	850	688.0	12.8	......	ne.	....
10:21 a. m....	714.7	17.0	73	ne.	5.8	526	714.7	17.0	73	ne.	5.8
July 19.											
3:26 p. m....	719.6	22.3	50	n.	2.2	526	719.6	22.3	50	n.	2.2
3:41 p. m....	719.6	21.9	49	nnw.	2.2	2904	541.6	3.4	......	nnw.	....
3:56 p. m....	719.6	22.6	48	e.	2.7	1774	621.6	10.2	......	n.	....
4:13 p. m....	719.6	22.9	52	nne.	2.2	1414	648.7	13.4	......	n.	....
4:23 p. m....	719.6	22.1	52	n.	2.2	921	687.5	17.7	......	n.	....
4:31 p. m....	719.6	21.7	51	n.	1.8	526	719.6	21.7	51	n.	1.8
July 20.											
2:29 p. m....	719.9	24.2	45	se.	3.1	526	719.9	24.2	45	se.	3.1
2:54 p. m....	719.8	23.9	47	ese.	3.6	2638	561.8	7.7	......	calm.	....
3:01 p. m....	719.8	24.2	48	ese.	2.7	2153	595.3	10.3	......	calm.	....
3:12 p. m....	719.8	23.9	44	ese.	2.2	1486	644.1	15.8	......	calm.	....
3:23 p. m....	719.7	23.9	44	se.	2.7	973	683.6	19.1	......	ssw.	....
3:29 p. m....	719.7	23.9	44	se.	2.2	526	719.7	23.9	44	se.	2.2
July 21.											
11:18 a. m....	718.3	22.4	58	s.	8.0	526	718.3	22.4	58	s.	8.0
11:30 a. m....	718.2	22.3	55	s.	8.0	835	693.1	18.5	......	s.	....
12:45 p. m....	717.8	23.3	57	s.	5.8	1314	655.0	14.0	......	s.	....
3:41 p. m....	716.9	23.4	56	sse.	6.3	842	691.4	19.3	......	s.	....
3:48 p. m....	716.9	23.2	55	se.	7.2	526	716.9	23.2	55	se.	7.2

July 18.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 4800 m.; at maximum altitude, 3000 m.

There were 10/10 St. from the west until 8:47 a. m. and 9/10 to 8/10 St.-Cu. from the west thereafter.

High pressure was central over Lake Superior and low pressure off the North Carolina coast.

July 19.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2700 m.

There were 2/10 to 3/10 Cu. from the north-northwest.

Pressure was high over Iowa and low over Georgia.

July 20.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2200 m.

There were 3/10 to 2/10 Cu. from the east.

Areas of high pressure were central over Ohio and Maine and areas of low pressure north of Lake Superior and off the coast of South Carolina.

July 21.—Five kites were used; lifting surface, 37.4 sq. m. Wire out, 2800 m.; at maximum altitude, 900 m.

There were few Cu. from the south-southwest until 3:28 p. m. The sky was cloudless thereafter.

Centers of high pressure lay over Alabama and off the coast of New Jersey. Low pressure was central over Ontario and off the South Carolina coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910.											
July 22.	*mm.*	°*C.*	%		*m. p. s.*	*m.*	*mm.*	°*C.*	%		*m. p. s.*
6:20 a. m....	716.3	18.8	69	w.	7.6	526	716.3	18.8	69	w.	7.6
6:37 a. m....	716.3	19.3	68	w.	7.2	670	704.6	22.0	......	nw.	....
7:00 a. m....	716.3	19.7	67	w.	7.2	1113	669.5	19.3	......	wnw.	....
8:21 a. m....	716.4	21.2	67	w.	5.4	1361	650.6	16.8	......	wnw.	....
8:31 a. m....	716.4	21.6	68	wsw.	4.9	2385	576.1	10.8	......	wsw.	....
8:55 a. m....	716.4	21.8	65	w.	5.4	1535	637.2	15.3	......	wnw.	....
9:07 a. m....	716.4	22.2	66	w.	5.4	1330	652.7	16.0	......	nw.	....
9:20 a. m....	716.4	22.8	66	w.	5.4	1017	677.0	18.9	......	w.	....
9:30 a. m....	716.4	22.6	64	w.	4.5	526	716.4	22.6	64	w.	4.5
July 23.											
6:19 a. m....	717.8	21.6	76	w.	9.8	526	717.8	21.6	76	w.	9.8
6:29 a. m....	717.8	21.8	68	w.	8.9	850	691.6	20.8	......	wnw.	....
8:15 a. m....	718.2	23.2	69	wnw.	8.0	1094	672.8	19.7	......	wnw.	....
8:50 a. m....	718.4	22.8	70	wnw.	5.4	1607	634.0	16.6	......	wnw.	....
8:57 a. m....	718.4	22.8	72	w.	4.9	2034	602.7	13.7	......	w.	....
9:05 a. m....	718.4	23.2	68	w.	5.4	2583	565.0	10.8	......	wsw.	....
9:27 a. m....	718.5	23.2	69	w.	5.4	1662	630.0	16.0	......	w.	....
9:35 a. m....	718.6	23.5	70	w.	6.3	1284	658.6	18.9	......	wnw.	....
9:50 a. m....	718.7	23.6	69	wnw.	7.2	841	693.3	21.3	......	wnw.	....
9:59 a. m....	718.7	23.4	68	wnw.	7.6	526	718.7	23.4	68	wnw.	7.6
July 24.											
6:17 a. m....	719.2	23.6	74	wsw.	5.4	526	719.2	23.6	74	wsw.	5.4
6:27 a. m....	719.2	24.2	71	wsw.	5.4	918	687.8	23.0	......	sw.	....
6:42 a. m....	719.3	24.2	71	sw.	4.9	1349	654.4	20.2	......	sw.	....
7:28 a. m....	719.3	24.8	71	w.	2.7	1786	622.1	16.5	......	sw.	....
8:31 a. m....	719.2	24.9	74	sw.	3.1	2388	579.2	11.5	......	sw.	....
9:20 a. m....	719.1	25.6	70	w.	4.5	3028	536.8	8.5	......	sw.	....
9:30 a. m....	719.1	25.6	72	sw.	4.5	2272	587.2	11.6	......	sw.	....
9:48 a. m....	719.0	26.4	68	sw.	4.5	1872	615.7	14.9	......	wsw.	....
9:58 a. m....	719.0	26.8	62	wsw.	4.5	1574	637.6	17.2	......	wsw.	....
10:08 a. m....	719.0	27.0	61	sw.	4.5	959	684.4	21.3	......	sw.	....
10:17 a. m....	718.9	27.0	61	sw.	4.5	526	718.9	27.0	61	sw.	4.5

July 22.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 3900 m.; at maximum altitude, 2500 m.

There were a few Ci.-St. from the west after 7:48 a. m.

Pressure was low over Quebec and high over Georgia.

July 23.—Eight kites were used; lifting surface, 50.9 sq. m. Wire out, 6000 m.; at maximum altitude, 3500 m.

There were 5/10 to 9/10 Ci.-St., A.-St., and A.-Cu. from the west. Solar halo, 6:30 to 7:30 a. m.

High pressure was central over the south Atlantic coast, low pressure over the lower St. Lawrence.

July 24.—Five kites were used; lifting surface, 36.4 sq. m. Wire out, 4200 m.; at maximum altitude, 3260 m.

There were few Cu. from the south-southwest during the flight.

Low pressure was central north of Lake Superior. High pressure was central off the Georgia coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910. July 25.	*mm.*	*° C.*	*%*		*m. p. s.*	*m.*	*mm.*	*° C.*	*%*		*m. p. s.*
6:23 a. m....	716.0	23.0	73	wsw.	6.3	526	716.0	23.0	73	wsw.	6.3
6:30 a. m....	716.0	22.9	73	wsw.	6.3	914	684.8	20.4	......	w.	....
6:46 a. m....	716.0	22.8	73	wsw.	7.6	1521	638.1	15.8	......	w.	....
6:50 a. m....	716.0	22.8	73	wsw.	8.0	1846	614.4	17.7	......	w.	....
7:38 a. m....	716.0	23.3	74	w.	8.0	2149	593.2	16.9	......	wnw.	....
7:53 a. m....	716.0	23.4	74	w.	8.0	3479	506.5	8.3	......	wnw.	....
8:18 a. m....	715.9	23.9	74	w.	8.0	3832	485.3	6.1	......	w.	....
9:02 a. m....	715.8	24.9	70	w.	8.5	4363	455.1	1.8	......	w.	....
9:41 a. m....	715.6	25.2	70	w.	7.6	3950	477.9	5.2	......	w.	....
10:17 a. m....	715.6	25.7	69	w.	8.0	2797	549.5	10.0	......	w.	....
10:31 a. m....	715.5	25.8	68	w.	8.5	2376	577.9	14.0	......	w.	....
10:50 a. m....	715.5	25.7	67	w.	7.6	1658	628.4	19.6	......	w.	....
10:59 a. m....	715.5	26.1	65	w.	8.5	1345	651.4	22.3	......	w.	....
11:05 a. m....	715.5	26.6	65	w.	8.5	1225	660.6	19.8	......	w.	....
11:16 a. m....	715.4	27.0	66	w.	7.6	891	686.5	22.6	......	w.	....
11:24 a. m....	715.4	27.4	59	w.	9.4	526	715.4	27.4	59	w.	9.4
July 26.											
6:25 a. m....	713.9	22.3	75	w.	5.8	526	713.9	22.3	75	w.	5.8
6:36 a. m....	714.0	22.0	78	w.	6.7	864	686.8	21.2	......	wnw.	....
6:49 a. m....	714.0	22.2	78	w.	7.2	1418	644.0	17.9	......	wnw.	....
7:01 a. m....	714.0	22.6	78	w.	7.2	1947	605.1	13.4	......	wnw.	....
7:16 a. m....	714.0	22.7	77	w.	6.7	2481	568.2	11.2	......	w.	....
7:23 a. m....	714.0	22.7	77	w.	6.7	2633	558.1	13.3	......	w.	....
7:52 a. m....	714.0	23.0	81	wnw.	6.7	3319	514.3	9.4	......	w.	....
8:20 a. m....	713.8	23.8	79	wnw.	7.2	3794	485.6	6.8	......	w.	....
9:15 a. m....	713.5	25.0	64	wnw.	9.8	526	713.5	25.0	64	wnw.	9.8
July 27.											
4:28 p. m....	711.4	24.4	73	s.	2.2	526	711.4	24.4	73	s.	2.2
4:34 p. m....	711.4	24.4	70	s.	2.2	1383	644.7	19.3	......	ssw.	....
4:55 p. m....	711.3	24.8	71	s.	1.8	526	711.3	24.8	71	s.	1.8

July 25.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 7500 m.; at maximum altitude, 7000 m.

There were from 2/10 to 3/10 Ci. from the west. From 1/10 to 3/10 A.-Cu. from the west were visible before 7 a. m.

Pressure was high over Alabama and low over Quebec.

July 26.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 7500 m., at maximum altitude.

There were few A.-St. from the west-northwest until 8:20 a. m. and 2/10 Ci.-Cu. from the west-northwest thereafter.

Centers of low pressure lay over New Brunswick and Lake Superior. High pressure was central off the Georgia coast.

July 27.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2400 m.

There were from 4/10 to 5/10 A.-Cu. from the west.

Pressure was low over Michigan and high over the Gulf States.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
July 28.	*mm.*	°*C.*	%		*m. p. s.*	*m.*	*mm.*	°*C.*	%		*m. p. s.*
6:54 a. m....	710.7	19.8	82	wnw.	15.2	526	710.7	19.8	82	wnw.	15.2
6:59 a. m....	710.7	19.9	81	wnw.	14.8	832	685.9	18.2	......	wnw.	....
7:11 a. m....	710.7	20.0	80	nw.	14.8	1119	662.4	17.2	......	nw.	....
7:24 a. m....	710.7	20.0	83	wnw.	11.6	1383	643.1	15.4	......	nw.	....
7:45 a. m....	710.7	20.4	83	wnw.	12.1	1591	627.7	17.3	......	nw.	....
8:34 a. m....	710.8	21.2	78	wnw.	13.0	2086	592.5	13.9	......	nw.	....
8:55 a. m....	710.8	21.6	78	nw.	12.5	2548	560.8	9.6	......	nw.	....
9:21 a. m....	710.8	22.1	69	nw.	13.0	3348	509.5	7.5	......	nw.	....
9:41 a. m....	710.9	22.2	60	nw.	14.3	2426	569.0	10.2	......	nw.	....
10:05 a. m....	710.9	22.6	60	wnw.	13.9	2140	588.8	14.2	......	nw.	....
10:20 a. m....	711.0	22.6	56	wnw.	13.4	1896	605.9	16.5	......	nw.	....
10:30 a. m....	711.1	22.9	56	wnw.	13.4	1628	625.5	14.5	......	nw.	....
10:53 a. m....	711.2	23.0	55	nw.	12.5	882	682.6	18.6	......	nw.	....
10:58 a. m....	711.3	23.4	52	nw.	10.7	526	711.3	23.4	52	nw.	10.7
July 29.											
4:17 p. m....	713.3	27.6	46	wsw.	4.9	526	713.3	27.6	46	wsw.	4.9
4:34 p. m....	713.2	28.9	44	s.	5.8	2267	582.7	12.2	......	w.	....
4:42 p. m....	713.2	28.9	44	se.	4.9	1797	616.0	14.6	......	w.	....
5:00 p. m....	713.1	28.8	45	sw.	4.5	1453	641.3	17.6	.....	ssw.	....
5:11 p. m....	713.1	28.0	48	ssw.	4.5	871	685.8	22.7	......	s.	....
5:22 p. m....	713.0	27.6	49	ssw.	9.4	526	713.0	27.6	49	ssw.	9.4
July 30.											
8:34 a. m....	710.8	19.6	96	w.	8.5	526	710.8	19.6	96	w.	8.5
8:42 a. m....	710.8	19.4	96	wnw.	8.5	840	685.3	17.3	......	nw.	....
9:03 a. m....	710.8	19.9	97	wnw.	8.5	1240	654.0	17.5	......	nw.	....
9:15 a. m....	710.9	20.0	96	wnw.	8.0	1758	615.6	14.6	......	nw.	....
9:30 a. m....	710.9	20.2	96	wnw.	8.9	2334	575.0	11.0	......	nw.	....
10:25 a. m....	711.0	22.7	88	wnw.	6.3	2845	541.0	7.8	......	nw.	....
10:48 a. m....	710.9	23.4	81	w.	7.6	4138	461.9	2.4	......	w.	....
11:41 a. m....	710.8	24.8	71	w.	6.3	3310	511.1	7.4	......	wnw.	....
11:44 a. m....	710.8	25.0	70	w.	5.4	3094	524.2	6.2	......	wnw.	....
11:54 a. m....	710.8	25.2	69	wnw.	4.6	2632	554.9	7.6	......	wnw.	....
12:16 p. m....	710.8	26.3	54	w.	6.7	1983	600.0	11.9	......	wnw.	....
12:36 p. m....	710.7	26.6	54	w.	6.3	122[illegible]	656.0	17.7	......	w.	....
12:52 p. m....	710.7	27.2	54	w.	8.5	824	687.0	22.8	......	w.	....
12:56 p. m....	710.7	27.2	53	w.	8.9	526	710.7	27.2	53	w.	8.9

July 28.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 7500 m.; at maximum altitude, 7000 m.

There were a few Cu. from the northwest, and 1/10 Ci.-St. from the northwest from 9:01 to 10:27 a. m.

Pressure was low over Maine and high over the Gulf coast.

July 29.—One balloon was used; capacity, 31.1 cu. m. Wire out, 3000 m., at maximum altitude.

There were 1/10 to few Cu. from the west until 4:37 p. m. and 1/10 Ci. from the west-northwest thereafter.

Areas of low pressure were central over Missouri and north of Lake Superior. Pressure was high off the coast of Louisiana.

July 30.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 5900 m.; at maximum altitude, 5500 m.

There were 1/10 to 5/10 St.-Cu. from the west before 10:35 a. m. and 6/10 to a few low St. from the northwest during the flight. Rain fell from 8:30 to 8:45 a. m.

Pressure was low over Quebec and high over the Dakotas.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
July 31.	*mm.*	*°C.*	*%*		*m. p. s.*	*m.*	*mm.*	*°C.*	*%*		*m. p. s.*
6:28 a. m....	714.5	14.9	78	w.	5.4	526	714.5	14.9	78	w.	5.4
6:42 a. m....	714.5	15.1	77	nw.	5.4	921	681.9	12.7	......	nnw.	....
6:55 a. m....	714.6	15.2	78	nw.	5.4	1394	644.7	11.7	......	nnw.	....
7:09 a. m....	714.6	15.4	77	nw.	5.4	1944	603.6	8.1	......	nw.	....
7:20 a. m....	714.6	15.6	80	nw.	5.8	2415	570.4	10.3	......	nw.	....
7:42 a. m....	714.7	15.7	79	nw.	6.3	2958	534.3	7.0	......	nw.	....
8:55 a. m....	714.8	17.0	73	nw.	7.2	3214	518.4	4.2	......	nw.	....
9:02 a. m....	714.8	17.2	69	nnw.	7.2	3574	495.3	2.4	......	nw.	....
9:18 a. m....	714.8	17.3	68	nw.	7.2	2896	538.1	6.3	......	nw.	....
9:32 a. m....	714.9	17.9	69	nw.	7.6	2593	558.5	8.1	......	nw.	....
9:41 a. m....	714.9	18.3	66	nw.	7.2	2357	574.8	8.1	......	nw.	....
9:51 a. m....	714.9	18.2	65	nnw.	7.6	1920	605.9	9.6	......	nnw.	....
10:02 a. m....	714.9	18.2	65	nnw.	7.6	1330	650.2	11.5	......	nnw.	....
10:14 a. m....	715.0	18.3	66	nw.	7.6	784	693.8	14.7	......	nnw.	....
10:22 a. m....	715.1	19.0	63	nnw.	7.6	526	715.1	19.0	63	nnw.	7.6
August 1.											
3:11 p. m....	716.9	25.4	50	s.	2.7	526	716.9	25.4	50	s.	2.7
3:27 p. m....	716.9	26.2	48	s.	2.2	2569	564.3	8.4	......	wsw.	....
3:41 p. m....	716.8	25.2	53	s.	2.7	2010	603.0	11.8	......	wsw.	....
3:53 p. m....	716.8	25.6	49	s.	2.7	1849	614.9	13.1	......	sw.	....
4:04 p. m....	716.8	25.4	50	s.	2.7	1216	662.2	18.0	......	s.	....
4:27 p. m....	716.8	25.0	52	s.	5.4	526	716.8	25.0	52	s.	5.4
August 2.											
2:19 p. m....	716.8	28.2	42	w.	1.8	526	716.8	28.2	42	w.	1.8
2:33 p. m....	716.8	28.2	44	wnw.	1.8	2580	563.9	9.3	......	w.	....
2:43 p. m....	716.8	28.8	42	sse.	1.3	1858	614.9	13.5	......	w.	....
3:07 p. m....	716.8	28.3	44	sw.	1.8	1435	646.0	18.3	......	calm.	....
3:18 p. m....	716.8	28.6	44	se.	3.1	858	690.5	23.7	......	se.	....
3:22 p. m....	716.8	28.3	42	ese.	2.2	526	716.8	28.3	42	ese.	2.2
August 3.											
1:14 p. m....	716.6	28.4	61	s.	7.6	526	716.6	28.4	61	s.	7.6
1:24 p. m....	716.5	27.7	63	s.	7.2	801	694.7	22.9	......	s.	....
1:43 p. m....	716.3	27.9	65	s.	6.3	1244	660.0	19.9	......	s.	....
2:54 p. m....	715.5	28.1	62	s.	5.8	1861	613.7	15.9	......	ssw.	....
3:22 p. m....	715.3	28.4	60	s.	7.6	2501	569.0	11.7	......	sw.	....
3:44 p. m....	715.1	28.2	59	s.	6.7	1751	621.5	16.9	......	ssw.	....
3:50 p. m....	715.0	28.2	58	s.	8.0	1353	650.7	20.1	......	s.	....
4:00 p. m....	715.0	28.2	56	s.	6.7	890	686.3	23.8	......	s.	....
4:06 p. m....	715.0	28.1	58	s.	7.2	526	715.0	28.1	58	s.	7.2

July 31.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 6500 m.; at maximum altitude, 5000 m.

The sky was cloudless until 8:15 a. m. There were few Cu. from the northwest thereafter.

Low pressure was central over Nova Scotia. Centers of high pressure lay over western Ontario, Illinois, and the Gulf of Mexico.

August 1.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2400 m.

There were 1/10 to 2/10 Ci.-Cu. from the west and 3/10 Cu. from the west-southwest.

Pressure was low over the Gulf of St. Lawrence and high over West Virginia.

August 2.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2800 m.

There were from 7/10 to 8/10 A.-St. and from few to 1/10 Cu. from the west-northwest.

Pressure was high over Ontario and the Virginia coast. Areas of low pressure lay over the lower St. Lawrence, the Gulf coast of Florida, and over Kansas.

August 3.—Five kites were used; lifting surface, 36.9 sq. m. Wire out, 4000 m.; at maximum altitude, 3000 m.

There were 5/10 to 7/10 Cu. from the south. The head kite was in the clouds once at an altitude of about 1600 m.

At 8 a. m. pressure was low north of Lake Superior and relatively high over New England.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
August 4.	mm.	C.	%		m. p. s.	m.	mm.	°C.	%		m. p. s.
7:17 a. m....	712.5	23.2	70	wsw.	5.4	526	712.5	23.2	70	wsw.	5.4
7:26 a. m....	712.5	23.5	70	wsw.	5.4	852	686.4	21.4	......	w.	....
7:51 a. m....	712.4	23.2	71	wsw.	5.4	1430	641.9	18.6	......	w.	....
8:04 a. m....	712.4	23.6	70	w.	6.3	1809	614.3	17.1	......	w.	....
8:24 a. m....	712.4	23.5	70	w.	6.3	2571	561.5	11.0	......	w.	....
8:46 a. m....	712.3	23.3	74	w.	5.4	3480	502.7	3.9	......	w.	....
9:03 a. m....	712.3	23.1	74	wsw.	5.8	3864	479.6	0.5	......	w.	....
9:18 a. m....	712.4	22.6	77	w.	6.7	4483	443.8	− 0.9	......	w.	....
9:27 a. m....	712.5	22.3	78	w.	5.8	3939	474.0	1.6	......	w.	....
10:04 a. m....	712.7	21.0	87	w.	7.6	3715	487.1	2.7	......	wsw.	....
10:24 a. m....	712.7	19.9	95	w.	7.6	3248	515.8	3.5	......	w.	....
10:47 a. m....	712.6	20.5	93	wsw.	5.4	2854	541.1	4.7	......	wnw.	....
11:02 a. m....	712.6	20.8	91	wsw.	5.4	2373	573.4	10.8	......	wnw.	....
11:14 a. m....	712.5	21.0	89	wsw.	6.7	1321	649.6	15.8	......	w.	....
11:42 a. m....	712.4	22.9	85	sw.	5.4	872	684.7	19.6	......	wsw.	....
11:47 a. m....	712.4	23.2	81	wsw.	5.8	526	712.4	23.2	81	wsw.	5.8
August 5.											
6:36 a. m....	713.3	18.1	67	wnw.	8.0	526	713.3	18.1	67	wnw.	8.0
6:48 a. m....	713.4	18.3	67	wnw.	8.0	967	677.6	15.2	......	wnw.	....
7:00 a. m....	713.4	18.5	66	wnw.	7.6	1362	646.6	12.2	......	wnw.	....
7:17 a. m....	713.4	18.5	65	wnw.	5.8	1774	615.5	8.5	......	w.	....
7:20 a. m....	713.4	18.5	65	wnw.	5.8	2091	592.4	11.1	......	w.	....
8:05 a. m....	713.5	19.2	69	wnw.	6.7	3370	507.6	3.4	......	wnw.	....
8:10 a. m....	713.5	19.4	69	wnw.	6.3	3532	497.5	3.8	......	wnw.	....
8:55 a. m....	713.4	19.9	65	ynw.	6.3	4532	429.4	− 3.2	......	wnw.	....
9:41 a. m....	713.5	20.3	53	wnw.	14.8	3903	475.2	1.8	......	wnw.	....
10:22 a. m....	713.5	20.8	50	wnw.	12.1	3218	516.9	7.0	......	wnw.	....
10:31 a. m....	713.5	20.7	50	wnw.	11.2	2938	534.7	6.3	......	wnw.	....
12:19 p. m....	713.1	24.1	36	wnw.	8.0	2526	562.6	6.4	......	w.	....
12:49 p. m....	713.0	24.0	31	wnw.	8.0	2047	596.1	8.4	......	w.	....
1:08 p. m....	713.0	24.6	31	wnw.	8.9	1466	639.2	13.0	......	w.	....
1:38 p. m....	712.9	24.8	30	wnw.	8.0	862	686.0	20.3	......	wnw.	....
1:47 p. m....	712.9	24.8	30	wnw.	8.9	526	712.9	24.8	30	wnw.	8.9

August 4.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 7500 m.; at maximum altitude, 7400 m.

There were 8/10 to 10/10 St.-Cu. from the west-southwest until 9 a. m. and from 11:18 a. m. until the end of the flight. From 9 a. m. until 11:18 a. m. there were 10/10 St. from the west.

A large area of low pressure was central over eastern Ontario. High pressure was central off the Georgia coast.

August 5.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 7500 m.; at maximum altitude, 7300 m.

Dense haze prevailed until 8:30 a. m.; light haze and few to 4/10 Cu. from the west-northwest thereafter.

At 8 a. m. low pressure was central over the Gulf of St. Lawrence and high pressure over the north-central States.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
August 6.	*mm.*	*° C.*	*%*		*m. p. s.*	*m.*	*mm.*	*° C.*	*%*		*m. p. s.*
6:50 a. m....	715.2	17.7	68	w.	7.2	526	715.2	17.7	68	w.	7.2
7:14 a. m....	715.2	18.0	65	w.	7.2	986	677.9	15.6	......	w.	....
7:44 a. m....	715.3	18.2	67	w.	7.2	1737	620.0	10.1	......	wnw.	....
7:46 a. m....	715.4	18.2	66	w.	6.7	1895	608.6	12.1	......	wnw.	....
7:56 a. m....	715.4	18.2	66	w.	6.7	2280	581.2	11.2	......	wnw.	....
8:14 a. m....	715.4	18.7	66	w.	6.7	3128	524.9	7.6	......	wnw.	....
8:40 a. m....	715.4	19.6	62	w.	6.7	3871	479.4	1.6	......	w.	....
9:21 a. m....	715.4	20.2	61	w.	6.7	4562	439.9	− 3.3	......	w.	....
10:09 a. m....	715.4	21.7	56	w.	7.2	3446	504.3	4.6	......	w.	....
10:40 a. m....	715.3	22.6	50	wsw.	7.2	3018	532.4	8.1	......	wnw.	....
11:00 a. m....	715.2	23.0	47	wnw.	8.5	2340	577.5	12.2	......	wnw.	....
11:20 a. m....	715.1	23.5	48	w.	8.5	1981	602.6	10.0	......	w.	....
11:31 a. m....	715.1	24.0	43	w.	8.5	1638	628.1	11.6	......	w.	....
11:41 a. m....	715.1	24.1	44	w.	8.5	1124	667.5	16.3	......	w.	....
11:55 a. m....	715.0	24.3	42	w.	8.5	526	715.0	24.3	42	w.	8.5
August 7.											
10:33 a. m....	717.1	21.8	54	nw.	1.3	526	717.1	21.8	54	nw.	1.3
10:50 a. m....	717.1	22.6	50	nw.	2.2	2090	596.6	11.0	......	wnw.	....
11:07 a. m....	717.1	23.1	45	w.	2.2	1480	641.5	13.0	......	wnw.	....
11:27 a. m....	717.0	24.0	43	wnw.	3.1	1058	674.5	17.9	......	sw.	....
11:34 a. m....	716.9	23.8	44	w.	3.1	819	693.3	20.7	......	calm.	....
11:39 a. m....	716.9	24.0	44	nnw.	3.1	526	716.9	24.0	44	nnw.	3.1
August 8.											
3:01 p. m....	715.1	16.8	98	nw.	6.7	526	715.1	16.8	98	nw.	6.7
3:45 p. m....	715.0	16.4	100	nw.	7.6	983	677.8	15.6	......	nw.	....
3:57 p. m....	715.0	16.6	98	nw.	8.5	1374	647.3	14.5	......	nw.	....
4:39 p. m....	714.9	17.0	96	nw.	7.6	1786	616.4	12.0	......	nnw.	....
4:59 p. m....	714.9	17.6	96	nw.	6.7	2618	557.5	6.9	......	nnw.	....
5:06 p. m....	714.9	17.3	96	nw.	6.3	2214	585.6	8.6	......	nnw.	....
5:14 p. m....	714.9	17.1	98	nnw.	6.3	1705	622.3	11.1	......	nnw.	....
5:27 p. m....	714.9	16.6	98	nw.	6.3	1346	649.4	13.9	......	n.	....
5:39 p. m....	714.9	16.6	98	nw.	5.4	878	686.2	17.1	......	n.	....
5:44 p. m....	714.9	17.0	98	nw.	4.9	526	714.9	17.0	98	nw.	4.9

August 6.—Seven kitee were used; lifting surface, 44.6 sq. m. Wire out, 7500 m.; at maximum altitude, 7200 m.

There were 6/10 A.-St. from the west until 8:30 a. m. and from 6/10 to a few Ci.-St. from the same direction thereafter. There were a few Cu. from the west after 10:28 a. m.

Pressure was low over the Gulf of St. Lawrence and high from Minnesota to Florida.

August 7.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2800 m.

There were 3/10 to 4/10 Ci.-Cu. from the west.

At 8 a. m. relatively high pressure covered the Eastern States.

August 8.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 4000 m.; at maximum altitude, 2800 m.

There was dense fog from the west from the beginning of the flight until 3:50 p. m.; light fog from 3:50 p. m. until 4:45 p. m.; and 6/10 to 5/10 St. from the northwest from 4:45 p. m. until the end of the flight. Light rain began 3:35 p. m. and ended at 3:45 p. m.

Centers of low pressure lay over Virginia and western Ontario. An area of high pressure extended from the St. Lawrence to the lower Mississippi.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
August 9.	*mm.*	°*C.*	%		*m. p. s.*	*m.*	*mm.*	°*C.*	%		*m. p. s.*
1:48 p.m....	716.8	22.5	69	e.	3.1	526	716.8	22.5	69	e.	3.1
2:00 p.m....	716.8	23.0	67	se.	2.7	2333	579.4	11.0	......	nw.	....
2:16 p.m....	716.7	23.5	67	ese.	3.1	1279	656.7	15.1	......	nw.	....
2:48 p.m....	716.6	24.1	65	ese.	3.6	838	691.4	18.9	......	calm.	....
2:55 p.m....	716.6	23.3	63	ese.	3.1	526	716.6	23.3	63	ese.	3.1
August 10.											
6:27 a.m....	715.5	17.1	99	s.	7.2	526	715.5	17.1	99	s.	7.2
6:33 a.m....	715.6	17.0	100	s.	7.2	967	680.0	20.1	......	sw.	....
6:50 a.m....	715.6	17.2	99	s.	6.3	1443	643.2	15.5	......	sw.	....
7:16 a.m....	715.7	17.6	95	s.	5.4	1890	610.2	11.3	......	wsw.	....
8:32 a.m....	715.6	17.5	98	sse.	4.9	2465	569.5	8.0	......	sw.	....
8:48 a.m....	715.6	17.7	96	s.	4.0	3530	500.0	2.4	......	sw.	....
9:12 a.m....	715.6	17.8	96	sse.	4.9	526	715.6	17.8	96	sse.	4.9
August 11.											
6:50 a.m....	717.4	17.0	85	wnw.	8.5	526	717.4	17.0	85	wnw.	8.5
6:57 a.m....	717.4	17.3	85	wnw.	7.6	862	689.8	18.7	......	wnw.	....
7:26 a.m....	717.4	18.1	80	nw.	8.0	1330	653.5	16.8	......	nw.	....
7:49 a.m....	717.4	18.6	80	nw.	8.9	1576	634.9	15.7	......	nw.	....
8:26 a.m....	717.6	19.3	77	nw.	9.8	2028	601.9	10.3	......	nw.	....
10:01 a.m....	718.2	21.4	66	nw.	6.7	2267	585.7	7.1	......	nw.	....
10:19 a.m....	718.3	21.9	65	nw.	4.5	1212	663.1	15.8	......	nw.	....
10:29 a.m....	718.3	22.1	64	nw.	4.5	688	705.1	19.6	......	nw.	....
10:32 a.m....	718.4	22.2	64	nw.	4.5	526	718.4	22.2	64	nw.	4.5
August 12.											
2:54 p.m....	719.1	23.2	61	e.	4.5	526	719.1	23.2	61	e.	4.5
3:13 p.m....	719.1	22.9	64	e.	4.5	3227	521.6	4.2	......	w.	....
3:28 p.m....	719.1	22.8	65	e.	4.5	2408	576.1	8.8	......	w.	....
3:37 p.m....	719.2	22.6	67	ese.	4.5	1653	630.7	12.7	......	calm.	....
3:56 p.m....	719.2	22.4	70	ese.	4.5	526	719.2	22.4	70	ese.	4.5

August 9.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2800 m.

There were a few Cu. from the northwest.

At 8 a. m. pressure was high over the Gulf of St. Lawrence and low over Lake Superior and off the Carolina coast.

August 10.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 5000 m.; at maximum altitude, 4000 m.

There was light fog from the beginning of the flight until 7 a. m. and dense fog from the southwest at intervals from 7:24 a. m. until the end of the flight. There were 10/10 A.-St. from the southwest from 7:04 a. m. until 7:35 a. m. and 10/10 St.-Cu. from the southwest until the end of the flight. Light rain began at 6:35 a. m. and continued at intervals until the end of the flight.

Low pressure was central over eastern Ontario. Centers of high pressure lay over New Brunswick and Kansas.

August 11.—Nine kites were used; lifting surface, 57.2 sq. m. Wire out, 6750 m.; at maximum altitude, 3600 m.

There were a few St.-Cu. from the northwest.

Pressure was low over the Gulf of St. Lawrence and the southern New England coast and high over the upper Lakes and the Ohio Valley.

August 12.—One balloon was used; capacity, 31.1 cu. m. Wire out, 3000 m.

There were 5/10 A.-St. and 5/10 St.-Cu. from the west until 3:34 p. m. and 10/10 St. from the west thereafter.

An area of high pressure was central over Lake Huron and an area of low pressure over North Dakota.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity					Dir.	Velocity.
1910. August 13.	*mm.*	*°C.*	*%*		*m. p. s.*	*m.*	*mm.*	*°C.*	*%*		*m. p. s.*
9:52 a. m....	720.7	18.8	100	ese.	4.5	526	720.7	18.8	100	ese.	4.5
10:15 a. m....	720.7	18.5	96	ese.	5.4	2495	571.4	10.6	......	ene.	....
10:29 a. m....	720.7	18.7	99	ese.	6.7	2103	598.8	11.6	......	e.	....
10:41 a. m....	720.7	18.8	98	ese.	6.3	1782	622.1	14.0	......	e.	....
11:02 a. m....	720.7	19.2	96	ese.	5.4	526	720.7	19.2	96	ese.	5.4
August 14.											
9:32 a. m....	720.0	21.6	51	ese.	3.1	526	720.0	21.6	51	ese.	3.1
9:43 a. m....	720.0	21.3	54	ese.	3.1	1678	629.3	14.1	......	ne.	....
10:03 a. m....	720.0	21.9	56	e.	3.6	1164	668.6	16.2	......	ene.	....
10:16 a. m....	719.9	21.8	62	e.	3.6	526	719.9	21.8	62	e.	3.6
August 15.											
4:15 p. m....	716.8	19.2	100	ese.	5.8	526	716.8	19.2	100	ese.	5.8
4:30 p. m....	716.8	19.4	100	ese.	5.8	898	686.4	15.7	......	ese.	....
4:58 p. m....	716.8	19.4	100	ese.	5.8	1032	675.7	17.7	......	ese.	....
5:35 p. m....	716.8	19.2	100	e.	5.4	1193	663.1	15.3	......	e.	....
5:47 p. m....	716.8	19.2	100	e.	5.4	944	682.8	16.5	......	e.	....
5:57 p. m....	716.8	19.2	100	e.	5.4	814	693.2	17.6	......	e.	....
6:08 p. m....	716.8	19.4	100	e.	5.4	526	716.8	19.4	100	e.	5.4
August 16.											
4:05 p. m....	716.9	24.2	76	ese.	3.6	526	716.9	24.2	76	ese.	3.6
4:16 p. m....	716.9	24.4	76	ese.	3.1	2012	603.0	13.5	......	nne.	....
4:27 p. m....	716.9	24.3	73	ese.	3.6	1283	656.8	17.4	......	nne.	....
5:08 p. m....	716.8	24.4	76	ese.	3.1	667	705.4	22.1	......	ene.	....
5:16 p. m....	716.8	24.3	78	ese.	2.7	526	716.8	24.3	78	ese.	2.7
August 17.											
2:00 p. m....	722.1	18.6	93	e.	5.4	526	722.1	18.6	93	e.	5.4
2:07 p. m....	722.1	18.6	95	e.	4.9	894	691.7	15.5	......	e.	....
3:09 p. m....	722.1	18.8	92	e.	5.4	1182	668.8	17.7	......	e.	....
3:27 p. m....	722.1	19.0	92	e.	5.4	1328	657.8	16.2	......	e.	....
3:36 p. m....	722.1	19.2	91	e.	5.4	1230	665.0	16.9	......	e.	....
3:46 p. m....	722.1	19.2	90	e.	5.4	1208	666.7	15.4	......	e.	....
3:56 p. m....	722.1	19.0	91	e.	5.4	852	695.1	15.5	......	e.	....
4:01 p. m....	722.1	19.0	91	e.	5.4	526	722.1	19.0	91	e.	5.4

August 13.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2800 m.
Dense fog prevailed throughout the ascension.
At 8 a. m. relatively high pressure covered the Eastern States.

August 14.—One balloon was used; capacity, 31.1 cu. m.
There were few Ci. and 4/10 A.-St. from the southwest during the ascension.
Areas of high pressure lay over Virginia and western Ontario. There were centers of low pressure over the lower St. Lawrence and Texas.

August 15.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 2400 m.; at maximum altitude, 1500 m.
There was dense fog.
Pressure was high over New England and Lake Superior and comparatively low over Kansas.

August 16.—One balloon was used; capacity, 31.1 cu. m. Wire out, 3000 m.
There were 3/10 to 2/10 A.-St. from the east, and few to 4/10 Cu. from the northeast during the ascension.
There was a center of high pressure over the lower St. Lawrence, and centers of low pressure off the coast of North Carolina, north of Lake Superior, over Wisconsin, and over Kansas.

August 17.—Four kites were used; lifting surface, 30.6 sq. m. Wire out, 2900 m.; at maximum altitude, 2500 m.
There were 10/10 St. from the east at an altitude of about 900 m. The head kite was in the clouds from 2:03 to 3:50 p. m.
Pressure was high over New Brunswick and low over Kansas.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m. Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	At different heights above sea. Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910.											
August 18.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
1:21 p. m....	720.9	20.0	95	se.	6.7	526	720.9	20.0	95	se.	6.7
1:31 p. m....	720.7	20.2	93	se.	5.8	847	694.4	17.5	......	sse.	....
1:51 p. m....	720.5	20.4	92	se.	6.3	950	685.9	19.8	......	s.	....
2:02 p. m....	720.4	20.9	90	se.	6.3	1525	641.4	15.6	......	s.	....
3:27 p. m....	719.6	21.4	89	sse.	7.2	1540	639.7	18.2	......	ssw.	....
3:30 p. m....	719.6	21.4	87	sse.	7.2	1370	652.5	18.5	......	ssw.	....
3:43 p. m....	719.5	21.6	87	se.	7.6	1200	665.4	18.6	......	s.	....
3:56 p. m....	719.3	21.4	84	s.	8.0	873	691.0	18.1	......	s.	....
4:05 p. m....	719.3	21.7	86	sse.	6.7	526	719.3	21.7	86	sse.	6.7
August 19.											
10:19 a. m....	717.7	19.8	100	nw.	8.0	526	717.7	19.8	100	nw.	8.0
10:28 a. m....	717.7	19.6	100	nw.	8.0	838	692.2	17.9	......	nnw.	....
10:54 a. m....	717.5	20.8	90	nw.	6.7	1352	651.7	15.5	......	nnw.	....
11:04 a. m....	717.5	21.8	90	nw.	6.3	1587	634.2	16.5	......	nnw.	....
11:37 a. m....	717.4	21.6	86	nw.	7.2	1561	636.0	14.0	......	nnw.	....
11:43 a. m....	717.4	21.6	82	nw.	6.7	2115	595.4	12.9	......	nnw.	....
11:58 a. m....	717.4	21.7	82	nw.	7.2	1582	634.2	14.1	......	nnw.	....
12:02 p. m....	717.4	22.0	81	nw.	4.5	1614	631.9	15.6	......	nnw.	....
12:11 p. m....	717.4	22.0	81	nw.	5.4	1272	657.8	15.1	......	nnw.	....
12:21 p. m....	717.3	21.9	82	nw.	6.7	837	692.2	18.6	......	nnw.	....
12:24 p. m....	717.3	22.0	82	nw.	6.7	526	717.3	22.0	82	nw.	6.7
August 20.											
1:44 p. m....	718.0	22.8	49	s.	5.4	526	718.0	22.8	49	s.	5.4
2:00 p. m....	717.9	22.5	47	s.	4.0	2940	538.7	3.7	......	w.	....
2:20 p. m....	717.8	23.0	44	se.	5.8	2148	593.2	8.6	......	w.	....
2:34 p. m....	717.8	24.0	43	se.	6.3	2037	601.2	9.3	......	w.	....
2:49 p. m....	717.7	23.5	45	se.	5.4	1510	640.1	13.6	......	s.	....
2:57 p. m....	717.7	23.0	47	se.	5.4	785	696.6	19.4	......	se.	....
3:02 p. m....	717.7	22.8	49	se.	5.4	526	717.7	22.8	49	se.	5.4
August 21.											
6:55 a. m....	718.8	16.8	87	sse.	5.8	526	718.8	16.8	87	sse.	5.8
7:10 a. m....	718.8	16.9	87	sse.	5.8	859	691.4	16.2	......	s.	....
7:17 a. m....	718.8	16.9	87	sse.	6.3	901	688.0	16.6	......	ssw.	....
7:42 a. m....	718.8	16.9	88	s.	5.8	1270	658.7	13.9	......	sw.	....
10:31 a. m....	718.8	18.4	85	sse.	9.8	1862	614.2	11.8	......	sw.	....
10:40 a. m....	718.8	18.1	88	sse.	8.9	1565	636.1	13.2	......	ssw.	....
11:01 a. m....	718.8	18.4	85	s.	8.5	1114	670.9	16.9	......	s.	....
11:15 a. m....	718.9	18.4	85	s.	8.9	817	694.8	14.8	......	s.	....
11:26 a. m....	719.0	18.5	86	s.	8.5	526	719.0	18.5	86	s.	8.5

August 18.—Five kites were used; lifting surface, 37.4 sq. m. Wire out, 3400 m.; at maximum altitude, 1800 m.

There were 9/10 to 6/10 St.-Cu. from the southeast during the flight.

There were centers of high pressure off the coast of Maine and over Minnesota. Centers of low pressure lay over eastern Ontario and over Missouri.

August 19.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 3300 m.; at maximum altitude, 2800 m.

There were 3/10 to 6/10 A.-St. and Ci.-St. from the northwest and 3/10 to 7/10 St. from the north-northwest. A solar halo was visible. The altitude of the St. layer about 1200 m.

At 8 a. m. pressure was high from the upper Lake region southwestward to Oklahoma and low off the New England coast.

August 20.—One balloon was used, capacity 31.1 cu. m. Wire out, 3100 m.

There were 2/10 to a few St.-Cu. from the northwest.

Pressure was high over Pennsylvania and low over Saskatchewan.

August 21.—Seven kites were used; lifting surface, 45.1 sq. m. Wire out, 5600 m.; at maximum altitude, 2600 m.

There were 10/10 to 5/10 St.-Cu. from the south-southwest and 1/10 to few A.-St. from the southwest during the flight.

The pressure was high off the New Jersey coast. Centers of low pressure lay over Manitoba and south of Alabama.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
August 22.	*mm.*	*°C.*	%		*m. p. s.*	*m.*	*mm.*	*°C.*	%		*m. p. s.*
1:07 p. m....	718.8	21.3	72	s.	6.7	526	818.8	21.3	72	s.	6.7
1:14 p. m....	718.7	21.9	71	s.	8.9	914	687.2	17.7	......	s.	....
1:22 p. m....	718.7	21.9	70	s.	8.9	1041	677.7	16.7	......	s.	....
1:36 p. m....	718.6	22.1	69	s.	9.4	1129	670.1	18.7	......	s.	....
2:10 p. m....	718.5	22.4	68	sse.	8.5	1614	633.1	15.2	......	s.	....
2:37 p. m....	718.4	22.4	67	s.	7.2	1901	611.5	12.7	......	ssw.	....
2:47 p. m....	718.3	22.4	66	s.	7.2	1404	648.3	16.1	......	s.	....
2:55 p. m....	718.3	22.3	68	s.	7.2	1235	661.3	14.8	......	s.	....
3:20 p. m....	718.2	22.0	70	s.	7.2	865	697.6	17.6	......	s.	....
3:28 p. m....	718.1	22.0	70	s.	5.8	526	718.1	22.0	70	s.	5.8
August 23.											
6:36 a. m....	719.0	18.4	94	ssw.	5.4	526	719.0	18.4	94	ssw.	5.4
6:45 a. m....	719.0	18.6	94	ssw.	5.4	792	697.1	18.0	......	s.	....
8:49 a. m....	719.3	20.0	88	s.	4.0	1253	661.0	16.4	......	s.	....
8:58 a. m....	719.3	20.2	86	ssw.	4.0	797	697.1	18.3	......	ssw.	....
9:02 a. m....	719.3	20.4	85	ssw.	4.0	526	719.3	20.4	85	ssw.	4.0
2d flight.											
1:50 p. m....	718.8	24.7	64	sse.	5.4	526	718.8	24.7	64	sse.	5.4
2:00 p. m....	718.8	24.8	66	sse.	6.3	820	695.1	21.0	......	s.	....
2:58 p. m....	718.3	24.8	66	s.	5.4	1078	674.2	18.5	......	s.	....
3:48 p. m....	718.3	24.4	69	sse.	5.4	1552	637.9	16.4	......	ssw.	....
3:55 p. m....	718.3	24.4	70	s.	4.9	1079	674.2	18.7	......	ssw.	....
4:06 p. m....	718.3	24.2	70	sse.	5.4	792	696.8	20.9	......	s.	....
4:12 p. m....	718.3	24.2	70	sse.	6.3	526	718.3	24.2	70	sse.	6.3
August 24.											
1:07 p. m....	721.0	25.8	62	s.	7.6	526	721.0	25.8	62	s.	7.6
1:30 p. m....	720.8	26.5	60	s.	6.3	1024	681.0	21.2	......	s.	....
2:13 p. m....	720.4	26.8	59	ssw.	6.7	1337	656.4	18.5	......	s.	....
3:51 p. m....	720.2	25.8	58	s.	5.8	1663	631.8	16.8	......	ssw.	....
3:57 p. m....	720.2	25.7	59	sse.	5.8	1457	647.1	18.2	......	s.	....
4:06 p. m....	720.2	25.5	59	s.	7.2	1361	654.3	18.1	......	s.	....
4:20 p. m....	720.2	25.3	61	s.	7.6	526	720.2	25.3	61	s.	7.6

August 22.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 300 m.; at maximum altitude, 1900 m.

There were 10/10 to 6/10 A.-St. and a few Cu. from the southwest.

An area of low pressure had centers over Lake Superior and over Nebraska. A center of high pressure lay off the New England coast.

August 23.—First flight: Four kites were used; lifting surface, 25.7 sq. m. Wire out, 2100 m.; at maximum altitude, 1800 m.

There was dense haze.

Second flight: Five kites were used; lifting surface, 36.9 sq. m. Wire out, 2400 m.; at maximum altitude, 1700 m.

There were few to 1/10 Cu. from the southwest and light haze.

At 8 a. m. pressure was low over Missouri and Iowa and high off the Middle Atlantic States.

August 24.—Six kites were used; lifting surface, 38. 3 sq. m. Wire out, 4100 m.; at maximum altitude, 3300 m.

There were few Cu. from the southwest.

A center of high pressure lay off the North Carolina coast. Low pressure was central over Iowa.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m. Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	At different heights above sea. Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. August 25.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
8:49 a. m....	720.4	19.2	98	s.	6.3	526	720.4	19.2	98	s.	6.3
9:00 a. m....	720.4	19.9	96	s.	6.3	932	687.3	19.5	......	sw.	....
10:37 a. m....	720.3	22.9	85	s.	5.8	1583	637.5	16.7	......	wsw.	....
11:02 a. m....	720.2	22.8	88	s.	6.3	2699	558.6	10.7	......	wsw.	....
11:22 a. m....	720.1	22.7	87	s.	6.7	3097	532.4	8.2	......	wsw.	....
11:47 a. m....	720.0	24.5	77	s.	5.8	3556	503.6	5.2	......	wsw.	....
12:46 p. m....	719.7	26.6	68	sse.	7.6	4020	475.7	2.7	......	wsw.	....
2:34 p. m....	719.0	27.7	60	s.	7.6	3267	521.2	7.4	......	wsw.	....
2:55 p. m....	718.8	27.7	59	s.	8.0	2596	565.0	11.2	......	wsw.	....
3:27 p. m....	718.6	27.4	58	s.	7.6	1810	619.8	15.2	......	wsw.	....
3:40 p. m....	718.5	27.4	58	s.	8.9	1288	658.5	19.2	......	sw.	....
3:54 p. m....	718.4	27.6	57	s.	8.0	874	690.7	23.1	......	ssw.	....
4:01 p. m....	718.4	27.8	55	s.	8.0	526	718.4	27.8	55	s.	8.0
August 26.											
6:28 a. m....	717.0	22.6	72	wsw.	6.3	526	717.0	22.6	72	wsw.	6.3
6:38 a. m....	717.1	22.6	72	w.	6.7	881	688.5	20.6	......	wsw.	....
6:50 a. m....	717.3	20.5	87	wnw.	11.2	1557	636.3	15.4	......	w.	....
7:18 a. m....	717.5	19.1	85	wnw.	8.0	1255	659.2	16.5	......	w.	....
7:44 a. m....	717.7	18.4	92	nw.	10.7	862	690.2	18.3	......	nw.	....
7:51 a. m....	717.8	17.8	92	nnw.	10.7	526	717.8	17.8	92	nnw.	10.7
2d flight.											
11:12 a. m....	718.8	16.8	75	nw.	13.9	526	718.8	16.8	75	nw.	13.9
11:23 a. m....	718.8	16.7	76	nw.	11.6	871	690.2	13.2	......	nw.	....
11:40 a. m....	718.8	16.6	76	nw.	14.3	938	684.9	18.9	......	w.	....
11:50 a. m....	718.8	16.3	77	nw.	14.3	1544	628.1	17.4	......	w.	....
12:10 p. m....	718.8	16.5	77	nw.	12.5	2423	575.2	10.4	......	wsw.	....
12:47 p. m....	718.8	15.5	80	nw.	13.0	3444	508.2	4.5	......	wsw.	....
1:34 p. m....	718.8	15.6	77	nw.	13.0	2495	569.6	9.6	......	wsw.	....
1:48 p. m....	718.8	15.5	78	nw.	9.8	1538	638.1	15.1	......	w.	....
2:01 p. m....	718.8	15.6	79	nw.	11.2	818	694.4	17.4	......	wnw.	....
2:13 p. m....	718.8	15.6	78	nw.	11.2	807	695.3	11.8	......	nw.	....
2:21 p. m....	718.8	15.5	78	nw.	9.4	526	718.8	15.5	78	nw.	9.4

August 25.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 7000 m., at maximum altitude.

There were 10/10 to a few St. from the south, 3/10 to a few St.-Cu. after 10:43 a. m., and a few to 5/10 Ci.-Cu. after 12:11 p. m., both from the west. The head kite was in the clouds from 9:02 to 10:05 a. m.

Pressure was high along the Virginia and Carolina coasts and low over Lake Michigan.

August 26.—First flight: Two kites were used; lifting surface, 13.1 sq. m. Wire out, 1200 m., at maximum altitude.

At the beginning of the flight there were 10/10 St.-Cu. from the west-southwest; these were later obscured by 10/10 St. from the west at an altitude of about 1500 m. Rain fell from 6:50 to 7:10 a. m. and from 7:47 a. m. until the end of the flight.

Second flight: Five kites were used; lifting surface, 31.5 sq. m. Wire out, 5000 m.; at maximum altitude, 4750 m.

There were 10/10 St.-Cu. from the west-southwest at an altitude of 2800 m. Rain fell from 1:35 p. m. until the close of the flight.

At 8 a. m. high pressure was central over Missouri, Iowa, and Kansas and low pressure over the lower St. Lawrence Valley.

Surface temperatures.

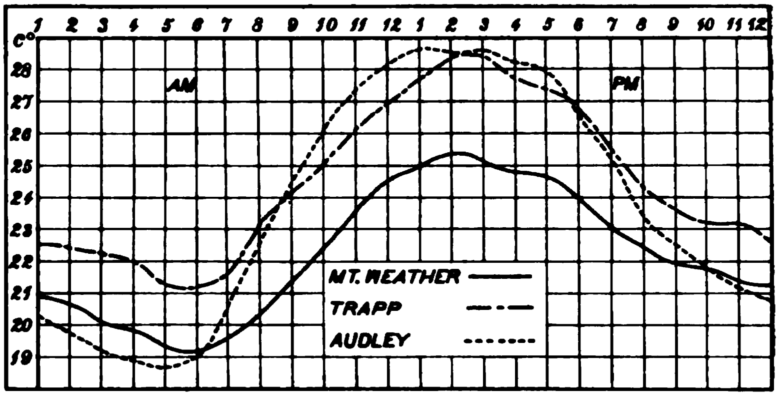


FIG. 8.—Mean hourly temperatures, July, 1910.

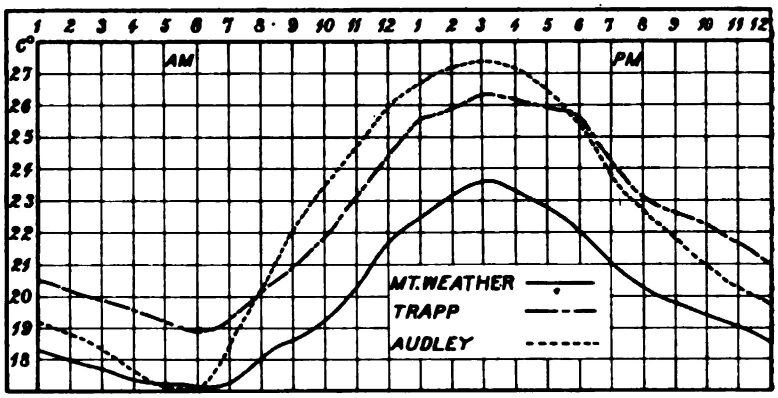


FIG. 9.—Mean hourly temperatures, August. 1910.

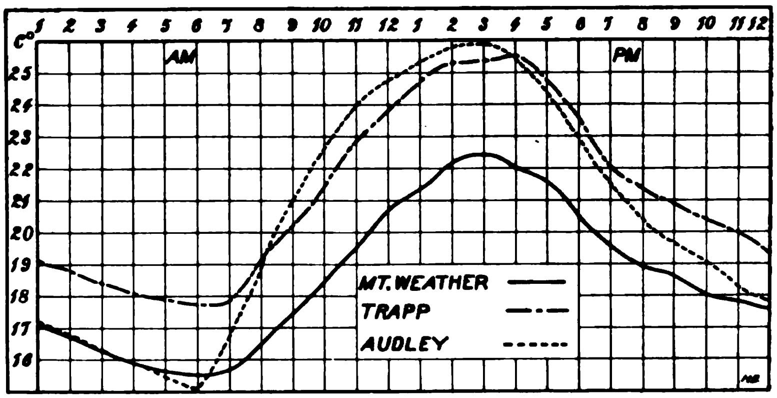


FIG. 10.—Mean hourly temperatures, September, 1910.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m. Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	At different heights above sea. Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. August 31.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
10:34 a. m....	723.0	18.3	86	ese.	5.4	526	723.0	18.3	86	ese.	5.4
11:58 a. m....	722.3	20.0	80	se.	6.7	1078	677.3	15.7	......	sse.	....
12:42 p. m....	722.1	20.1	83	se.	7.6	1230	665.2	17.5	......	s.	....
1:09 p. m....	722.0	20.4	82	se.	7.6	1588	637.8	14.2	......	ssw.	....
1:26 p. m....	721.9	20.7	80	se.	7.2	1801	621.9	14.4	......	ssw.	....
1:42 p. m....	721.8	20.6	80	sse.	6.3	2120	598.6	12.5	......	s.	....
1:46 p. m....	721.8	20.6	81	se.	5.8	1822	620.1	14.2	......	s.	....
1:53 p. m....	721.7	20.8	80	se.	5.8	1665	631.7	14.0	......	ssw.	....
1:58 p. m....	721.7	20.7	80	se.	6.3	1273	661.5	16.2	......	s.	....
2:07 p. m....	721.6	20.6	82	se.	6.7	1180	668.6	15.3	......	sse.	....
2:17 p. m....	721.6	20.5	82	se.	6.7	923	689.1	16.6	......	sse.	....
2:28 p. m....	721.4	20.0	86	se.	5.8	526	721.4	20.0	86	se.	5.8
September 1.											
2:30 p. m....	715.4	19.6	100	nw.	7.2	526	715.4	19.6	100	nw.	7.2
2:45 p. m....	715.4	19.7	98	nw.	6.3	795	693.4	16.5	......	nw.	....
3:06 p. m....	715.4	20.0	96	nw.	7.2	1153	665.0	15.6	......	nw.	....
3:16 p. m....	715.4	20.4	96	nw.	7.6	1354	640.5	16.7	......	nw.	....
3:46 p. m....	715.4	20.8	89	nw.	7.6	2098	595.0	13.3	......	nw.	....
4:20 p. m....	715.4	21.2	88	nw.	6.3	2538	564.8	10.5	......	nnw.	....
5:03 p. m....	715.4	22.2	83	nw.	6.3	3559	500.6	5.7	......	nnw.	....
5:20 p. m....	715.4	22.3	85	nw.	5.8	2781	540.0	9.4	......	nnw.	....
5:35 p. m....	715.4	20.9	92	nw.	6.3	2419	573.1	11.6	......	nnw.	....
5:53 p. m....	715.4	20.4	91	nw.	5.8	1802	616.4	14.8	......	nw.	....
6:03 p. m....	715.4	20.3	91	nw.	6.7	1304	653.4	16.7	......	nw.	....
6:15 p. m....	715.6	20.2	93	nw.	6.7	862	688.3	18.1	......	nw.	....
6:20 p. m....	715.7	20.2	93	nw.	7.2	526	715.1	20.2	93	nw.	7.2
September 2.											
10:43 a. m....	719.2	17.2	90	ne.	2.2	526	719.2	17.2	90	ne.	2.2
11:00 a. m....	719.2	17.2	92	ne.	2.2	2271	585.6	11.4	......	nw.	....
11:32 a. m....	719.2	16.8	96	n.	1.3	1573	636.0	15.0	......	nw.	....
11:42 a. m....	719.2	17.0	96	nne.	1.8	1395	649.4	16.9	......	ene.	....
11:49 a. m....	719.2	17.4	94	ene.	2.2	779	698.1	14.8	......	ene.	....
11:58 a. m....	719.2	71.4	92	e.	2.2	526	719.2	17.4	92	e.	2.2

August 31.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 3400 m.; at maximum altitude, 3000 m.

There were 10/10 St.-Cu. from the south during the flight. Light rain began at 2:17 p. m. and continued during the remainder of the flight.

Centers of high pressure lay off the coast of Massachusetts and over Minnesota. Low pressure was central over the lower St. Lawrence and over the Gulf of Mexico.

September 1.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 5500 m.; at maximum altitude, 4600 m.

There were 9/10 low St. from the northwest at the beginning which gradually disappeared, 3/10 to 6/10 St.-Cu. from the northwest after 3:20 p. m., and 1/10 Ci.-Cu. from the west after 5:14 p. m.

Pressure was high over Lake Superior and Georgia and comparatively low over northern Virginia.

September 2.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2600 m.

There were 10/10 St. from the east-northeast at an altitude of 900 m.

At 8 a. m. pressure was high over the upper Lakes and the Southeastern States, and relatively low over Virginia and Maryland.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910.											
September 3.	*mm.*	*°C.*	*%*		*m. p. s.*	*m.*	*mm.*	*°C.*	*%*		*m. p. s.*
11:25 a. m....	713.1	19.6	100	s.	7.6	526	713.1	19.6	100	s.	7.6
11:32 a. m....	713.1	19.8	98	s.	7.2	830	688.4	18.2	......	s.	....
12:09 p. m....	712.9	20.4	93	s.	6.7	1249	655.4	16.5	......	ssw.	....
12:22 p. m....	712.7	20.9	92	s.	8.0	1768	616.6	14.6	......	wsw.	....
12:37 p. m....	712.7	20.8	89	s.	8.0	2300	578.9	12.2	......	wsw.	....
1:27 p. m....	712.4	21.0	89	s.	5.8	2867	540.7	7.9	......	w.	....
2:01 p. m....	712.3	21.7	90	s.	3.6	3470	502.6	4.7	......	w.	....
2:23 p. m....	712.1	21.1	96	s.	2.7	3007	531.3	6.0	......	w.	....
3:00 p. m....	711.8	20.2	96	wsw.	6.3	1490	635.8	12.6	......	w.	....
3:22 p. m....	711.8	20.9	91	sw.	5.8	816	688.4	18.5	......	sw.	....
3:30 p. m....	711.8	21.2	93	sw.	4.9	526	711.8	21.2	93	sw.	4.9
September 4.											
2:27 p. m....	715.1	28.8	59	s.	4.5	526	715.1	28.8	59	s.	4.5
2:40 p. m....	715.1	28.8	55	se.	4.5	2344	579.4	13.1	......	wnw.	....
2:55 p. m....	715.1	27.7	62	s.	4.0	1499	639.6	17.3	......	wsw.	....
3:02 p. m....	715.1	27.2	64	s.	4.0	888	686.3	21.5	......	wsw.	....
3:23 p. m....	715.1	28.2	60	s.	4.0	526	715.1	28.2	60	s.	4.0
September 5.											
1:36 p. m....	717.3	24.9	75	wsw.	6.7	526	717.3	24.9	75	wsw.	6.7
1:43 p. m....	717.3	24.9	75	wsw.	5.8	887	688.4	22.2	......	wsw.	....
1:59 p. m....	717.2	25.6	77	wsw.	5.8	1445	645.7	19.5	......	w.	....
2:15 p. m....	717.2	25.8	72	wsw.	6.3	1900	612.3	16.9	......	w.	....
2:39 p. m....	717.1	26.5	69	wsw.	8.0	2559	556.8	14.0	......	wnw.	....
3:09 p. m....	716.9	26.9	67	wsw.	8.0	3380	513.8	8.3	......	wnw.	....
3:30 p. m....	716.9	27.4	66	wsw.	6.7	3805	487.7	5.2	......	wnw.	....
3:55 p. m....	716.9	27.6	66	sw.	6.7	3206	518.2	8.9	......	wnw.	....
4:18 p. m....	716.9	27.8	68	s.	4.9	2403	577.0	12.7	......	wnw.	....
4:35 p. m....	716.9	27.3	72	s.	3.6	1898	612.3	15.7	......	w.	....
4:47 p. m....	716.9	27.0	72	s.	4.5	1467	643.9	19.1	......	w.	....
4:57 p. m....	716.9	26.6	73	s.	4.5	928	685.0	23.5	......	wsw.	....
5:07 p. m....	716.9	26.5	76	s.	3.6	526	716.9	26.5	76	s.	3.6

September 3.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 5900 m.; at maximum altitude, 5000 m.

At the beginning of the flight there were 2/10 to 4/10 A.-Cu. from the west and about 8/10 St. from the south; the St. were at an altitude of about 800 m. and had dissipated by 1 p. m. Thereafter the sky was covered with St.-Cu. from the west and west-southwest at an altitude of about 3000 m. Rain fell after 2:05 p. m.

At 8 a. m. pressure was high off the New England coast and low over the upper Lakes.

September 4.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2800 m.

There were 5/10 St.-Cu. and a few Cu., both from the southwest.

Pressure was high over Florida and low over the Gulf of St. Lawrence.

September 5.—Four kites were used; lifting surface, 30.1 sq. m. Wire out 6000 m.; at maximum altitude, 5300 m.

There were about 8/10 A.-Cu. from the west. Very light rain fell from 1:40 to 1:59 p. m.

At 8 a. m. a moderate low was central over the Dakotas; pressure was relatively high over the St. Lawrence Valley and the Southeastern States.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m. Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	At different heights above sea. Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. September 6.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
6:33 a. m....	718.0	24.2	70	wsw.	5.8	526	718.0	24.2	70	wsw.	5.8
6:45 a. m....	718.0	24.6	68	wsw.	6.2	798	696.1	23.2	......	w.	....
7:13 a. m....	718.0	25.0	67	wsw.	4.0	1239	661.7	19.8	......	w.	....
7:26 a. m....	718.0	25.2	68	wsw.	4.0	1563	637.4	18.5	......	w.	....
7:53 a. m....	718.0	25.5	68	wsw.	3.6	1727	625.5	19.8	......	w.	....
8:01 a. m....	718.0	25.8	67	wsw.	3.6	1810	619.6	18.8	......	w.	....
8:38 a. m....	718.0	26.8	65	sw.	3.1	2513	570.8	14.8	......	w.	....
9:13 a. m....	718.0	27.5	65	sw.	3.1	3290	520.7	9.0	......	w.	....
10:02 a. m....	717.8	28.5	62	sw.	3.6	3850	486.4	5.1	......	w.	....
10:27 a. m....	717.7	28.2	59	w.	4.0	4603	443.2	0.0	......	w.	....
11:45 a. m....	717.4	29.6	56	w.	6.3	3969	479.0	5.1	......	w.	....
12:27 p. m....	717.3	30.1	52	wsw.	6.7	3283	520.7	10.1	......	w.	....
12:32 p. m....	717.3	29.9	53	wsw.	6.7	3056	534.8	12.1	......	w.	....
12:47 p. m....	717.2	29.8	55	sw.	5.4	2740	555.2	11.0	......	w.	....
1:00 p. m....	717.2	29.9	55	sw.	4.5	2386	579.0	14.0	......	w.	....
1:19 p. m....	717.1	29.0	57	w.	4.0	1164	667.1	22.2	......	w.	....
1:30 p. m....	717.1	28.4	57	w.	5.8	526	717.1	28.4	57	w.	5.8
September 7.											
6:25 a. m....	720.1	19.2	85	wnw.	8.0	526	720.1	19.2	85	wnw.	8.0
6:32 a. m....	720.1	19.0	85	wnw.	8.0	868	692.0	17.4	......	nw.	....
6:45 a. m....	720.2	19.2	84	wnw.	7.2	1356	653.6	14.4	......	nw.	....
6:54 a. m....	720.3	19.6	82	wnw.	7.6	1670	629.9	13.2	......	nw.	....
7:06 a. m....	720.3	19.8	80	wnw.	7.6	1852	616.6	16.4	......	nw.	....
7:13 a. m....	720.3	19.8	80	wnw.	7.6	2245	588.9	16.6	......	nw.	....
7:56 a. m....	720.4	20.4	78	wnw.	8.9	2628	563.1	14.3	......	nw.	....
9:56 a. m....	720.4	22.7	60	wnw.	12.1	3068	535.1	12.1	......	nnw.	....
10:14 a. m....	720.4	22.8	59	wnw.	10.3	2666	561.2	14.7	......	nw.	....
10:32 a. m....	720.4	23.1	57	wnw.	11.6	2166	595.2	17.2	......	nw.	....
10:44 a. m....	720.4	23.4	57	wnw.	13.9	1787	622.1	18.1	......	nw.	....
10:58 a. m....	720.4	23.3	55	wnw.	13.4	1339	665.4	15.7	......	nw.	....
11:13 a. m....	720.4	23.9	53	wnw.	11.6	876	692.0	19.4	......	nw.	....
11:24 a. m....	720.4	23.8	53	wnw.	13.0	526	720.4	23.8	53	wnw.	13.0
September 8.											
1:59 p. m....	718.5	26.0	48	w.	1.8	526	718.5	26.0	48	w.	1.8
2:42 p. m....	718.4	27.6	48	se.	2.2	1606	634.4	16.3	......	sw.	....
2:55 p. m....	718.3	27.4	49	se.	1.8	1152	668.8	19.5	......	calm.	....
3:04 p. m....	718.3	28.0	48	se.	2.2	526	718.3	28.0	48	se.	2.2

September 6.—Eight kites were used; lifting surface, 51.4 sq. m. Wire out, 8000 m.; at maximum altitude, 7800 m.

There were 3/10 to a few Ci.-St. from the west, and after 9:36 a. m. a few to 2/10 St.-Cu. from the west at an altitude of 1500 m.

Pressure was high over Georgia and low over Lake Superior.

September 7.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 8000 m.; at maximum altitude, 5300 m.

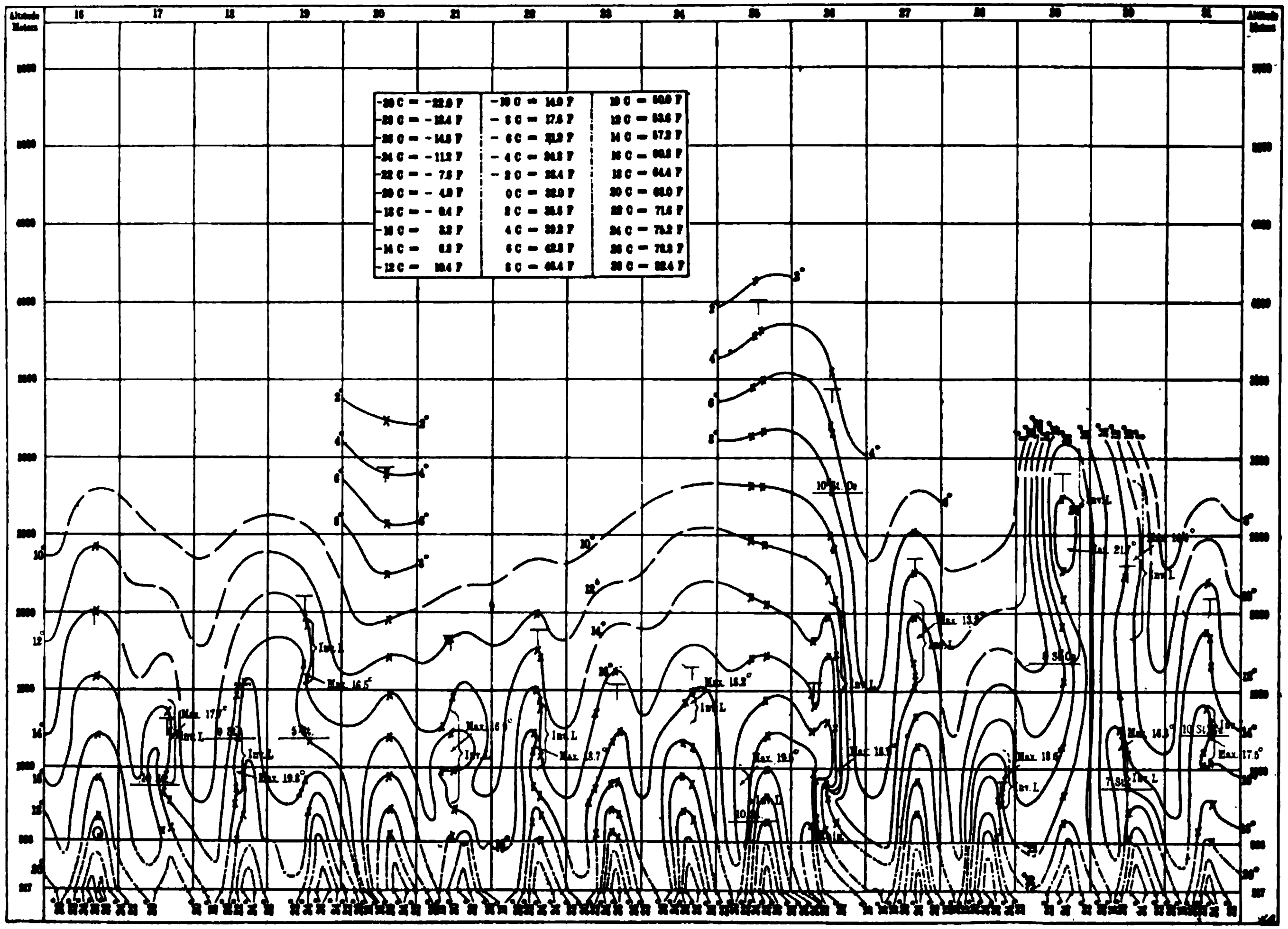
There were few to 2/10 A.-Cu. from the northwest, and after 8 a. m. about 2/10 Cu. also from the northwest. The Cu. were continually forming and dissipating above the mountain and were at an altitude of about 1800 m.

At 8 a. m. high pressure covered the States from the Lake region southward to the Gulf of Mexico and a low was central over Maine.

September 8.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2900 m.

There was light haze.

Pressure was high over Virginia and low over Lake Superior.



Free air isotherms, August 16–31, 1910.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. September 13.	*mm.*	*° C.*	*%*		*m. p. s.*	*m.*	*mm.*	*° C.*	*%*		*m. p. s.*
10:08 a. m....	720.5	22.5	82	wnw.	4.5	526	720.5	22.5	82	wnw.	4.5
10:34 a. m....	720.3	22.3	81	wnw.	7.2	929	687.6	19.4	......	wnw.	....
11:16 a. m....	720.1	22.4	81	wnw.	6.7	1134	671.3	20.0	......	wnw.	....
12:30 p. m....	719.7	23.1	70	wnw.	8.5	1412	649.2	17.1	......	wnw.	....
12:46 p. m....	719.6	24.7	70	wnw.	7.2	1965	608.6	13.3	......	nw.	....
1:08 p. m....	719.6	24.5	66	wnw.	4.9	1414	649.2	17.1	......	nw.	....
1:11 p. m....	719.6	24.1	65	wnw.	4.9	1337	655.0	16.4	......	nw.	....
1:19 p. m....	719.6	23.7	70	wnw.	5.4	878	691.1	19.6	......	nw.	....
1:35 p. m....	719.5	23.5	70	wnw.	7.2	526	719.5	23.5	70	wnw.	7.2
September 14.											
8:20 a. m....	720.5	15.0	96	nnw.	6.7	526	720.5	15.0	96	nnw.	6.7
8:29 a. m....	720.5	15.0	94	nnw.	5.4	930	686.9	11.8	......	n.	....
8:53 a. m....	720.5	15.2	94	nnw.	5.8	1265	659.8	10.9	......	nnw.	....
9:00 a. m....	720.5	15.2	94	nnw.	4.9	1410	648.7	14.7	......	nnw.	....
10:51 a. m....	720.5	17.4	86	nnw.	6.3	1957	608.1	10.9	......	nnw.	....
11:24 a. m....	720.5	17.8	75	nnw.	6.7	1314	656.3	13.8	......	nnw.	....
11:30 a. m....	720.5	18.0	72	n.	6.3	1131	670.8	12.2	......	n.	....
11:37 a. m....	720.5	17.8	68	n.	5.4	756	701.3	14.6	......	n.	....
11:44 a. m....	720.5	18.0	69	nnw.	8.0	526	720.5	18.0	69	nnw.	8.0
September 15.											
6:44 a. m....	722.4	7.8	75	nnw.	7.2	526	722.4	7.8	75	nnw:	7.2
7:51 a. m....	722.4	9.5	72	nnw.	6.3	727	704.3	11.1	......	nne.	....
8:16 a. m....	722.4	10.0	70	nw.	5.4	1172	668.5	8.4	......	nne.	....
8:39 a. m....	722.3	10.5	73	nnw.	5.8	1744	623.8	7.1	......	nne.	....
9:06 a. m....	722.2	10.8	78	nnw.	6.7	1840	616.6	7.5	......	nne.	....
9:55 a. m....	721.7	12.1	72	nw.	5.4	2118	596.0	7.4	......	nne.	....
10:20 a. m....	721.5	12.9	72	nw.	4.9	2797	547.7	3.2	......	nne.	....
10:34 a. m....	721.5	13.4	66	n.	4.0	2387	576.0	4.8	......	nne.	....
10:37 a. m....	721.5	13.5	66	n.	4.5	2108	596.0	7.0	......	nne.	....
10:45 a. m....	721.4	13.8	65	nw.	4.0	1878	613.0	6.7	......	nne.	....
10:51 a. m....	721.3	13.8	65	nnw.	1.0	1559	627.0	7.5	......	nne.	....
11:03 a. m....	721.3	14.3	68	nw.	5.4	1049	677.6	8.7	......	n.	....
11:09 a. m....	721.2	14.5	63	nw.	5.4	727	704.3	11.7	......	n.	....
11:12 a. m....	721.2	14.6	62	nnw.	4.9	526	721.2	14.6	62	nnw.	4.9

September 13.—Six kites were used; lifting surface, 43.7 sq. m. Wire out, 4200 m.; at maximum altitude, 3400 m.

There were 8/10 to 10/10 A.-Cu. and Cu. from the northwest. A few St. from the southwest were visible at intervals.

At 8 a. m. pressure was moderately high over the Eastern States and relatively low over the Gulf of Mexico.

September 14.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 3600 m.; at maximum altitude, 2700 m.

There were from 10/10 to 2/10 St. from the north. From 2/10 to 4/10 A.-Cu. from the west-northwest were visible after 9:26 a. m. Solar halo.

Pressure was high over Iowa and low off the North Carolina coast.

September 15.—Seven kites were used; lifting surface, 45.1 sq. m. Wire out, 4000 m.; at maximum altitude, 3300 m.

There were a few A.-Cu. from the north-northeast.

At 8 a. m. high pressure central over Chicago covered the Middle and Eastern States.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. September 16.	*mm.*	°*C.*	%		*m. p. s.*	*m.*	*mm.*	°*C.*	%		*m. p. s.*
4:16 p. m....	721.9	18.7	46	ne.	7.2	526	721.9	18.7	46	ne.	7.2
4:25 p. m....	721.9	18.4	41	ne.	6.7	924	682.1	14.9	......	ne.	......
4:39 p. m....	722.0	18.2	45	ne.	4.5	1216	665.7	12.5	......	nne.	......
5:14 p. m....	722.0	17.7	41	ne.	2.6	1668	630.5	7.7	......	nne.	......
5:48 p. m....	722.1	16.6	44	ne.	3.1	1935	610.1	5.3	......	nne.	......
5:55 p. m....	722.1	16.4	42	ne.	3.6	1766	622.7	6.4	......	ne.	......
6:05 p. m....	722.1	16.2	41	ne.	4.0	1351	654.7	9.6	......	ne.	......
6:14 p. m....	722.1	16.0	46	ne.	4.0	945	687.3	13.5	......	ne.	......
6:20 p. m....	722.2	15.9	43	ne.	4.5	526	722.2	15.9	43	ne.	4.5
September 17.											
3:55 p. m....	719.6	20.4	35	nw.	3.6	526	719.6	20.4	35	nw.	3.6
4:14 p. m....	719.6	19.8	36	nw.	3.6	2346	579.2	7.2	......	nne.	......
4:21 p. m....	719.6	19.8	39	nnw.	3.6	1836	616.2	7.1	......	nnw.	......
4:26 p. m....	719.6	19.8	36	nw.	2.7	1566	636.6	10.1	......	nnw.	......
4:41 p. m....	719.6	20.0	37	nw.	2.7	1297	657.1	12.0	......	nnw.	......
4:50 p. m....	719.6	19.8	40	nnw.	2.2	889	689.8	16.0	......	nnw.	......
4:56 p. m....	719.6	19.3	39	nw.	2.2	526	719.6	19.3	39	nw.	2.2
September 18.											
7:07 a. m....	718.8	13.4	65	w.	7.2	526	718.8	13.4	65	w.	7.2
7:52 a. m....	718.8	13.5	65	wnw.	7.2	862	691.0	17.5	......	nw.	......
9:02 a. m....	718.9	15.3	56	w.	6.7	1138	663.0	17.2	......	n.	......
9:26 a. m....	718.9	17.4	52	w.	5.8	1622	632.5	13.5	......	nnw.	......
9:39 a. m....	719.0	17.6	51	w.	5.8	1869	613.9	10.5	......	nnw.	......
9:55 a. m....	719.0	17.5	51	nnw.	5.8	1446	645.5	13.7	......	nnw.	......
10:05 a. m....	719.0	17.6	50	wnw.	5.4	1116	671.2	16.2	......	nw.	......
10:13 a. m....	719.0	17.8	49	wnw.	5.8	911	687.5	17.5	......	nw.	......
10:20 a. m....	719.1	17.6	51	wnw.	5.8	526	719.1	17.6	51	wnw.	5.8
September 19.											
10:02 a. m....	716.5	17.0	88	nw.	1.8	526	716.5	17.0	88	nw.	1.8
10:23 a. m....	716.5	17.3	87	nw.	1.3	2356	576.0	8.0	......	nnw.	......
10:36 a. m....	716.5	17.4	86	nw.	0.9	1841	613.0	9.2	......	nnw.	......
10:44 a. m....	716.5	18.3	85	nw.	0.9	1770	618.4	10.1	......	nnw.	......
10:48 a. m....	716.5	18.6	82	nw.	0.9	1329	651.8	12.6	......	nnw.	......
10:58 a. m....	716.5	18.8	76	nw.	3.1	872	688.2	14.7	......	nw.	......
11:08 a. m....	716.5	19.2	78	nw.	3.6	526	716.5	19.2	78	nw.	3.6

September 16.—Four kites were used; lifting surface, 30.6 sq. m. Wire out, 2550 m.; at maximum altitude, 2000 m.

There were 2/10 to 4/10 St.-Cu. from the northeast.

Pressure was high over Maine and low over Saskatchewan.

September 17.—One balloon was used; capacity 31.1 cu. m. Wire out 2900 m.

The sky was cloudless.

An area of high pressure covered the country east of the Mississippi, except the upper Lake region. A low pressure area was central over northern Minnesota.

September 18.—Five kites were used; lifting surface, 32.5 sq. m. Wire out, 3600 m.; at maximum altitude, 3200 m.

There were 4/10 Ci. from the northwest and after 8:46 a. m. 1/10 A.-St. from the north. Solar halo.

Pressure was high over Tennessee and low over the Gulf of St. Lawrence.

September 19.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2600 m.

There were 10/10 St.-Cu. from the north-northwest at an altitude of 1800 m.

At 8 a. m. pressure was high over the St. Lawrence Valley and the Gulf States and low over Indiana and off the Virginia coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. September 20.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
1:58 p. m....	714.8	24.4	63	wsw.	3.6	526	714.8	24.4	63	wsw.	3.6
2:11 p. m....	714.5	25.0	62	wsw.	3.6	2337	577.8	10.5	......	nw.	....
2:22 p. m....	714.3	24.3	56	w.	3.6	1862	611.2	13.6	......	nw.	....
2:32 p. m....	714.0	25.0	55	w.	3.6	1604	629.8	12.8	......	wnw.	....
2:42 p. m....	713.7	25.0	50	wsw.	4.5	1357	648.2	15.6	......	wnw.	....
2:52 p. m....	713.4	25.0	51	w.	3.6	863	686.4	20.1	......	w.	....
3:00 p. m....	713.3	24.2	57	wnw.	3.6	526	713.3	24.2	57	wnw.	3.6
September 21.											
3:10 p. m....	715.2	23.2	67	n.	2.7	526	715.2	23.2	67	n.	2.7
3:21 p. m....	715.2	22.5	60	nnw.	4.0	2267	582.6	9.6	......	nnw.	....
3:39 p. m....	715.2	21.8	62	nnw.	4.5	1900	608.6	10.3	......	c.	....
3:48 p. m....	715.2	21.3	66	n.	4.5	1640	627.7	11.6	......	e.	....
4:13 p. m....	715.3	20.7	70	nnw.	3.6	526	715.3	20.7	70	nnw.	3.6
September 22.											
7:02 a. m....	720.3	13.9	62	e.	6.3	526	720.3	13.9	62	e.	6.3
7:09 a. m....	720.3	14.0	62	e.	6.3	775	699.4	13.2	......	e.	....
7:27 a. m....	720.4	14.0	62	e.	6.3	1040	678.0	14.8	......	e.	....
9:32 a. m....	721.0	15.4	58	e.	6.3	1341	654.4	11.2	......	e.	....
9:50 a. m....	721.1	15.9	58	e.	6.3	872	692.2	14.0	......	e.	....
9:57 a. m....	721.1	15.9	58	e.	6.3	784	699.4	12.5	......	e.	....
10:01 a. m....	721.1	16.0	58	e.	6.3	526	721.1	16.0	58	e.	6.3
September 23.											
8:48 a. m....	721.9	14.0	100	se.	6.3	526	721.9	14.0	100	se.	6.3
8:51 a. m....	721.9	13.9	100	se.	6.3	695	707.6	13.2	......	s.	....
9:02 a. m....	721.9	13.8	100	se.	6.7	1122	672.0	15.7	......	s.	....
9:09 a. m....	721.9	13.8	100	sse.	6.3	1417	649.9	14.8	......	s.	....
9:35 a. m....	721.9	13.9	100	se.	7.6	1686	629.7	15.8	......	s.	....
10:42 a. m....	721.8	15.6	94	se.	7.2	2259	588.6	12.5	......	sw.	....
11:06 a. m....	721.7	16.2	90	se.	7.2	1687	629.7	15.9	......	sw.	....
11:23 a. m....	721.7	16.5	89	se.	7.6	1417	649.9	15.2	......	ssw.	....
11:29 a. m....	721.7	16.6	90	se.	8.0	1156	670.2	17.1	......	s.	....
11:37 a. m....	721.6	16.4	92	se.	8.0	906	690.1	14.3	......	s.	....
11:41 a. m....	721.6	16.4	92	se.	8.0	526	721.6	16.4	92	se.	8.0

September 20.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2500 m.
There were 4/10 to 2/10 Cu. from the northwest.
The pressure was relatively high over the Gulf States and low over the Northeastern States.

September 21.—One balloon was used; capacity, 31.1 cu. m. Wire out, 2500 m.
There were 5/10 to 7/10 St.-Cu. from the west. The balloon was in the clouds at 3:21 p. m.
Pressure was low over Maine and high over Minnesota.

September 22.—Seven kites were used; lifting surface, 50.0 sq. m. Wire out, 3700 m.; at maximum altitude, 2100 m.
There were no clouds.
At 8 a. m. pressure was high north of the lower Lakes and low over Minnesota and the Dakotas.

September 23.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 5000 m.; at maximum altitude, 4500 m.
There were 9/10 to 10/10 St. from the south-southeast at an altitude of 600 to 700 m. and light fog from 8:53 to 9:50 a. m.
Pressure was high over the New England coast and low over Kansas.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Air pres.	Air temp.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. September 24.	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
10:47 a. m....	720.8	18.1	95	se.	5.8	526	720.8	18.1	95	se.	5.8
10:50 a. m....	720.8	18.1	95	se.	6.7	633	711.8	16.5	......	s.	....
11:09 a. m....	720.6	18.9	91	s.	5.8	892	690.6	20.3	......	s.	....
11:21 a. m....	720.6	18.5	94	se.	6.7	1075	676.1	19.2	......	s.	....
1:54 p. m....	719.1	24.7	64	se.	8.9	1062	676.1	20.4	......	s.	....
1:58 p. m....	719.1	24.7	64	se.	8.9	1272	659.8	18.4	......	s.	....
1:59 p. m....	719.1	25.0	64	se.	8.9	1176	667.3	18.3	......	s.	....
2:06 p. m....	719.1	24.9	64	sse.	9.8	1061	676.1	19.1	......	s.	....
2:17 p. m....	719.0	24.7	62	s.	6.7	834	694.1	20.6	......	s.	....
2:23 p. m....	719.0	24.2	63	s.	6.7	526	719.0	24.2	63	s.	6.7
September 25.											
8:47 a. m....	719.3	19.8	85	sse.	5.4	526	719.3	19.8	85	sse.	5.4
9:36 a. m....	719.3	20.7	85	sse.	6.3	646	709.4	18.4	......	s.	....
9:48 a. m....	719.3	20.7	84	se.	7.2	755	700.6	21.0	......	s.	....
11:52 a. m....	718.6	24.5	66	se.	6.7	972	682.8	19.5	......	ssw.	....
12:21 p. m....	718.4	24.6	63	sse.	8.9	526	718.4	24.6	63	sse.	8.9
September 26.											
1:40 p. m....	716.9	24.3	62	w.	0.9	526	716.9	24.3	62	w.	0.9
2:10 p. m....	716.8	27.1	51	calm.	0.0	2596	562.5	9.3	......	calm.	....
2:18 p. m....	716.7	28.0	50	calm.	0.0	2254	586.2	11.0	......	calm.	....
2:30 p. m....	716.6	26.6	51	calm.	0.0	1810	617.7	13.3	......	calm.	....
2:38 p. m....	716.6	27.1	52	calm.	0.0	1408	647.5	16.9	......	calm.	....
2:44 p. m....	716.6	27.0	52	calm.	0.0	1029	676.7	20.3	......	calm.	....
2:54 p. m....	716.5	26.4	54	calm.	0.0	526	716.5	26.4	54	calm.	0.0
September 27.											
10:42 a. m....	717.6	25.8	60	se.	2.7	526	717.6	25.8	60	se.	2.7
11:09 a. m....	717.6	26.3	61	se.	4.0	3132	527.7	6.4	......	sw.	....
11:25 a. m....	717.4	26.3	58	s.	4.0	2092	598.0	11.9	......	sw.	....
11:47 a. m....	717.3	26.7	53	s.	4.0	1626	631.8	15.4	......	sw.	....
11:55 a. m....	717.3	26.8	54	s.	3.6	1357	652.0	17.3	......	sw.	....
12:14 p. m....	717.3	26.6	57	s.	3.6	526	717.3	26.6	57	s.	3.6

September 24.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 3700 m.; at maximum altitude, 1700 m.

There were 9/10 to 10/10 St. from the south and a few to 3/10 Ci. from the southwest; the former decreased rapidly after 11:21 a. m.

At 8 a.m. low pressure was central over southeastern Wisconsin. The pressure was high over the St. Lawrence Valley and the Atlantic coast States.

September 25.—Five kites were used; lifting surface, 33.0 sq. m. Wire out, 2850 m.; at maximum altitude, 1600 m.

At the beginning of the flight there were 5/10 St.-Cu. from the southwest and St. from the south; altitude of St., 900 m. These had dissipated by noon. Thereafter there were about 3/10 Cu. from the south.

At 8 a. m. pressure was moderately low north of the Lake region and high over the Gulf of St. Lawrence.

September 26.—One balloon was used; capacity, 22.4 cu. m. Wire out, 2600 m.

There were 3/10 to 4/10 Cu. from the west-southwest.

At 8 a. m. moderately high pressure overlay the Lake region and a low was central over southern Minnesota.

September 27.—Two balloons were used; capacity, 36.5 cu. m. Wire out 3400 m.

There were 4/10 to a few Ci.-Cu. and Ci.-St. and a few to 3/10 Cu., all from the southwest.

Pressure was low over the upper Lake region and high over New Brunswick.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Air pres.	Air temp.	Rel. hum.	Wind.		Height.	Air pres.	Air temp.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
September 28.	*mm.*	*°C.*	*%*		*m. p. s.*	*m.*	*mm.*	*°C.*	*%*		*m. p. s.*
6:31 a. m....	717.7	16.8	96	nw.	7.6	526	717.7	16.8	96	nw.	7.6
6:40 a. m...	717.8	16.8	96	nw.	8.0	891	687.8	14.7	......	nnw.	....
6:58 a. m....	717.9	16.8	96	nw.	6.7	1348	651.4	11.0	......	nw.	....
7:20 a. m....	718.0	16.8	96	nw.	5.8	1695	625.2	14.3	......	nw.	....
11:39 a. m....	718.9	19.4	61	nw.	10.7	2455	572.0	8.5	......	wnw.	....
11:50 a. m....	718.8	18.6	62	nw.	10.7	2323	581.1	10.2	......	nw.	....
12:04 p. m....	718.8	19.2	61	nw.	7.6	1755	621.7	14.5	......	nw.	....
12:14 p. m....	718.8	18.9	61	nw.	8.0	1217	662.6	12.0	......	nw.	....
12:24 p. m....	718.8	18.8	59	nw.	8.0	835	693.3	15.0	......	nnw.	....
12:32 p. m....	718.8	19.6	57	nw.	8.9	526	718.8	19.6	57	nw.	8.9
September 29.											
1:32 p. m....	720.9	18.6	61	n.	2.7	526	720.9	18.6	61	n.	2.7
2:00 p. m....	720.7	19.0	44	nw.	1.8	3035	534.7	6.7	......	n.	....
2:14 p. m....	720.7	18.7	59	nw.	2.2	2317	583.0	10.6	......	nw.	....
2:35 p. m....	720.6	18.3	56	nw.	1.8	2108	597.6	11.4	......	nw.	....
2:45 p. m....	720.6	18.4	52	nw.	2.2	1694	627.8	13.5	......	nw.	....
2:52 p. m....	720.6	18.3	57	nnw.	1.8	1352	653.8	11.4	......	e.	....
2:56 p. m....	720.6	18.6	60	nnw.	1.8	1101	673.7	13.9	......	e.	....
3:05 p. m....	720.6	20.2	46	n.	1.8	526	720.6	20.2	46	n.	1.8
September 30.											
7:00 a. m....	720.6	13.0	83	s.	6.7	526	720.6	13.0	83	s.	6.7
10:40 a. m....	720.1	14.7	87	sse.	8.0	879	690.8	14.2	......	ssw.	....
10:56 a. m....	719.9	15.0	86	sse.	7.2	1052	678.6	13.3	......	ssw.	....
11:05 a. m....	719.9	15.2	85	sse.	7.6	1667	628.8	10.6	......	sw.	....
11:24 a. m....	719.7	15.5	85	sse.	6.7	1991	604.8	11.8	......	sw.	....
11:30 a. m....	719.6	15.9	84	sse.	6.7	1686	627.0	10.8	......	sw.	....
11:56 a. m....	719.4	17.0	78	sse.	6.7	1322	654.7	12.1	......	sw.	....
12:00 p. m....	719.4	17.4	77	sse.	7.2	1160	667.5	13.8	......	sw.	....
12:04 p. m....	719.4	17.1	78	sse.	7.2	848	692.6	13.2	......	sw.	....
12:13 p. m....	719.3	17.0	77	sse.	7.6	526	719.3	17.0	77	sse.	7.6

September 28.—Ten kites were used; lifting surface, 63.5 sq. m. Wire out, 9000 m.; at maximum altitude, 3000 m.

There were 8/10 to 5/10 St.-Cu. from the northwest until 8:14 a. m. and again after 9:21 a. m. 10/10 to a few St. from the north-northwest were visible from 7:54 to 9:21 a. m. There were from a few to 3/10 A.-Cu. from the west after 11:30 a. m.

Pressure was high over Illinois and low over the Gulf of St. Lawrence.

September 29.—Two balloons were used; capacity, 36.5 cu. m. Wire out, 3500 m.

There were 2/10 to 4/10 Ci. from the southwest. Solar halo.

High pressure was central over the lower Lake region and low pressure over Manitoba.

September 30.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 6000 m.; at maximum altitude, 2800 m.

There were 10/10 St. from the south before 10 a. m. and from the south-southwest thereafter. The head kite was in the clouds at intervals from 7:12 to 11:27 a. m.

Pressure was high over the southern New England coast and low over Manitoba.

Surface temperatures.

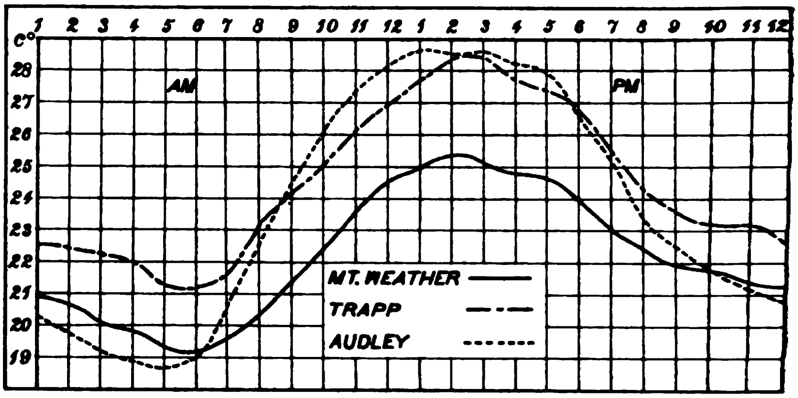


FIG. 8.—Mean hourly temperatures, July, 1910.

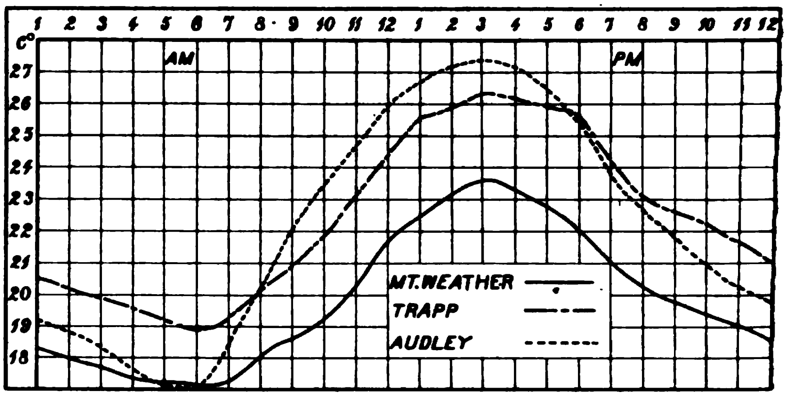


FIG. 9.—Mean hourly temperatures, August, 1910.

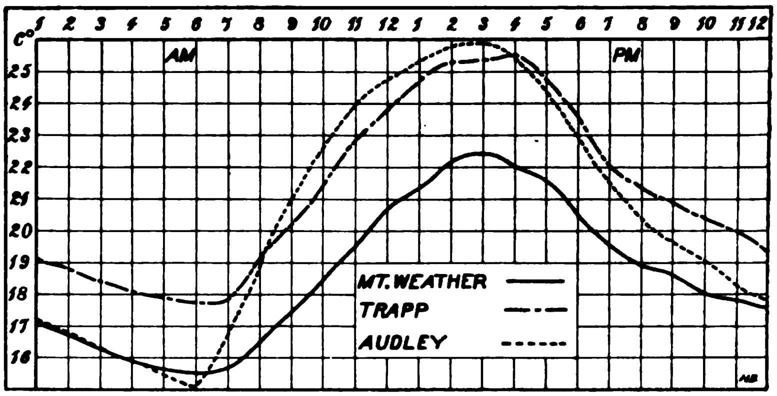
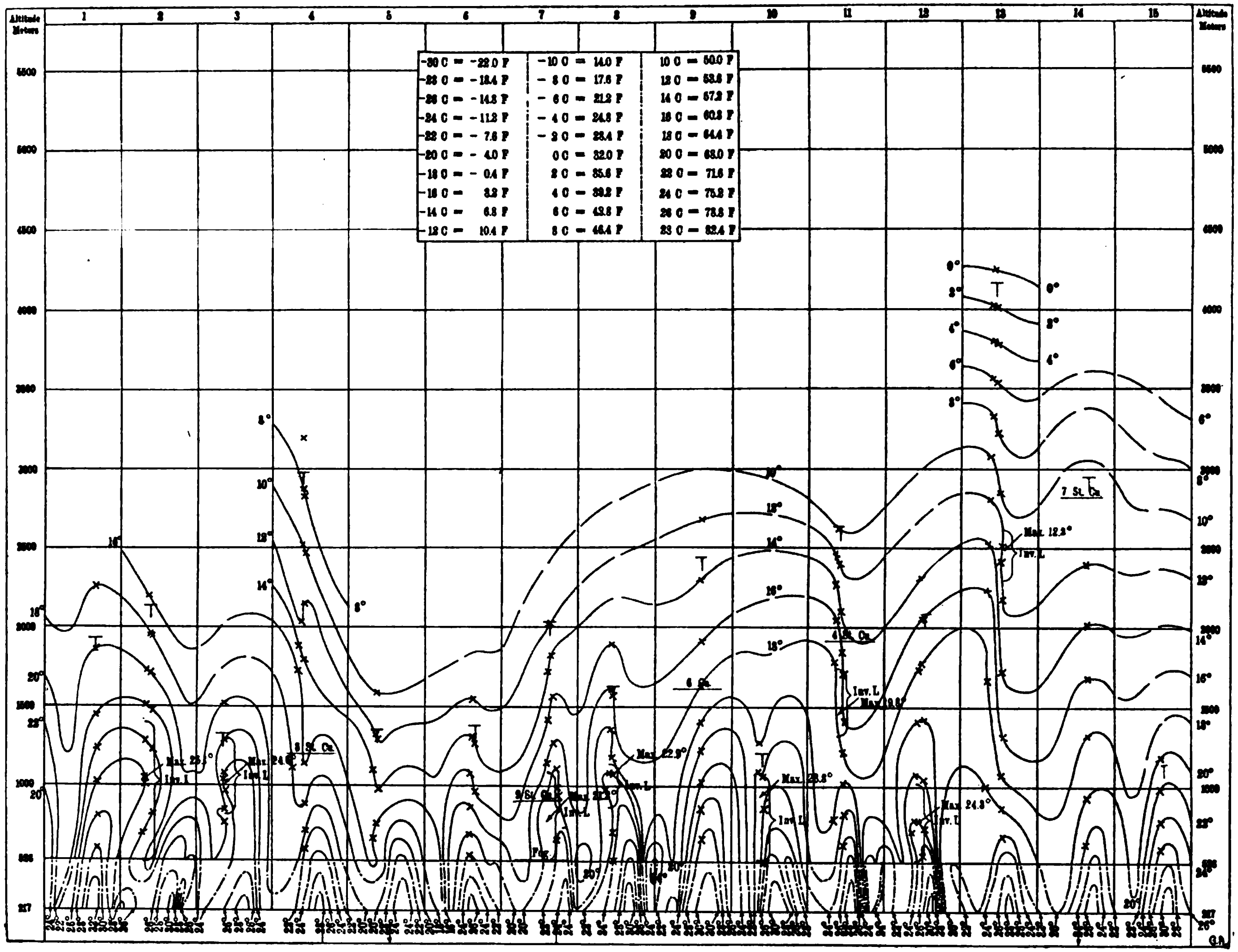
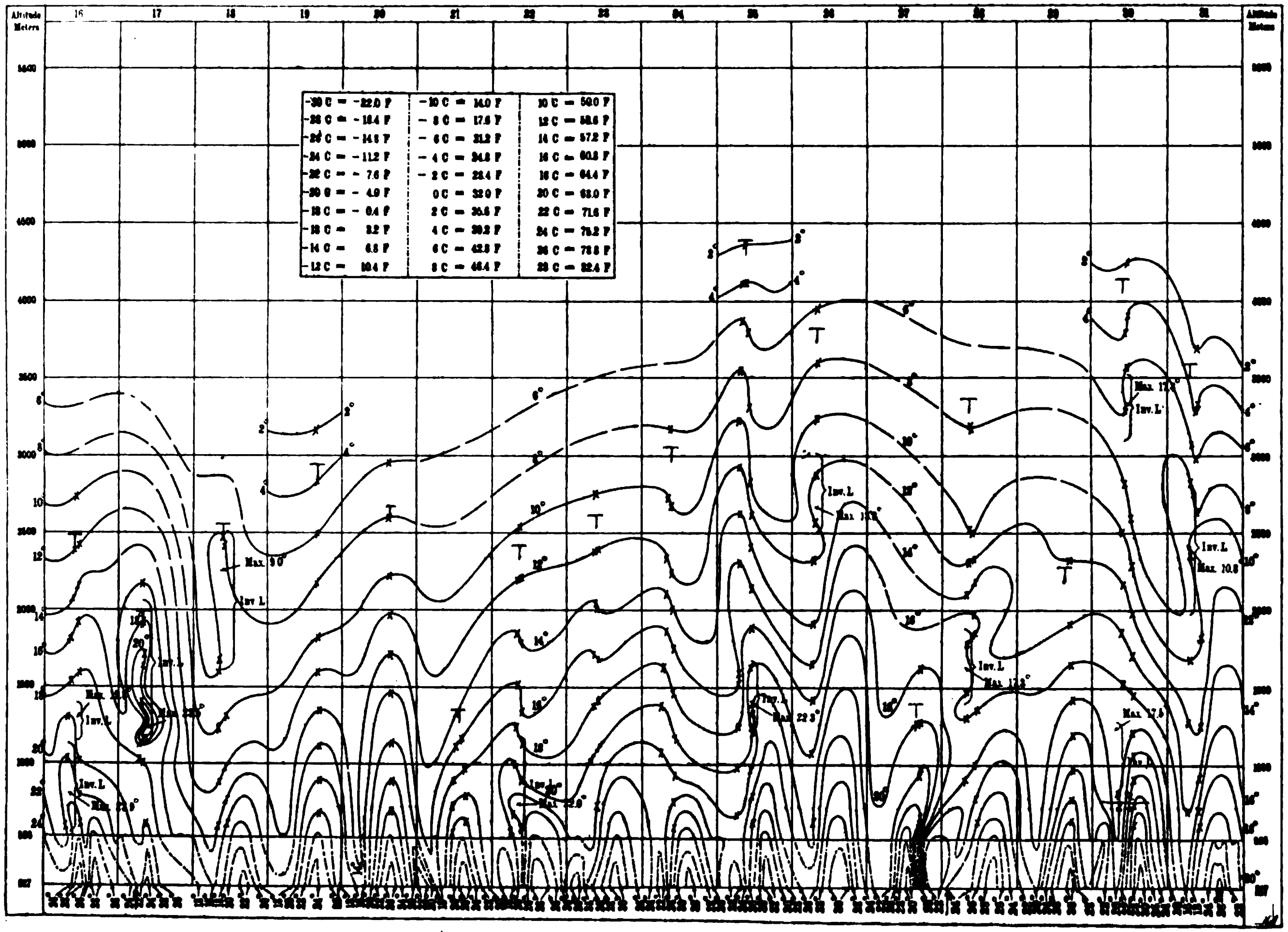


FIG. 10.—Mean hourly temperatures, September, 1910.

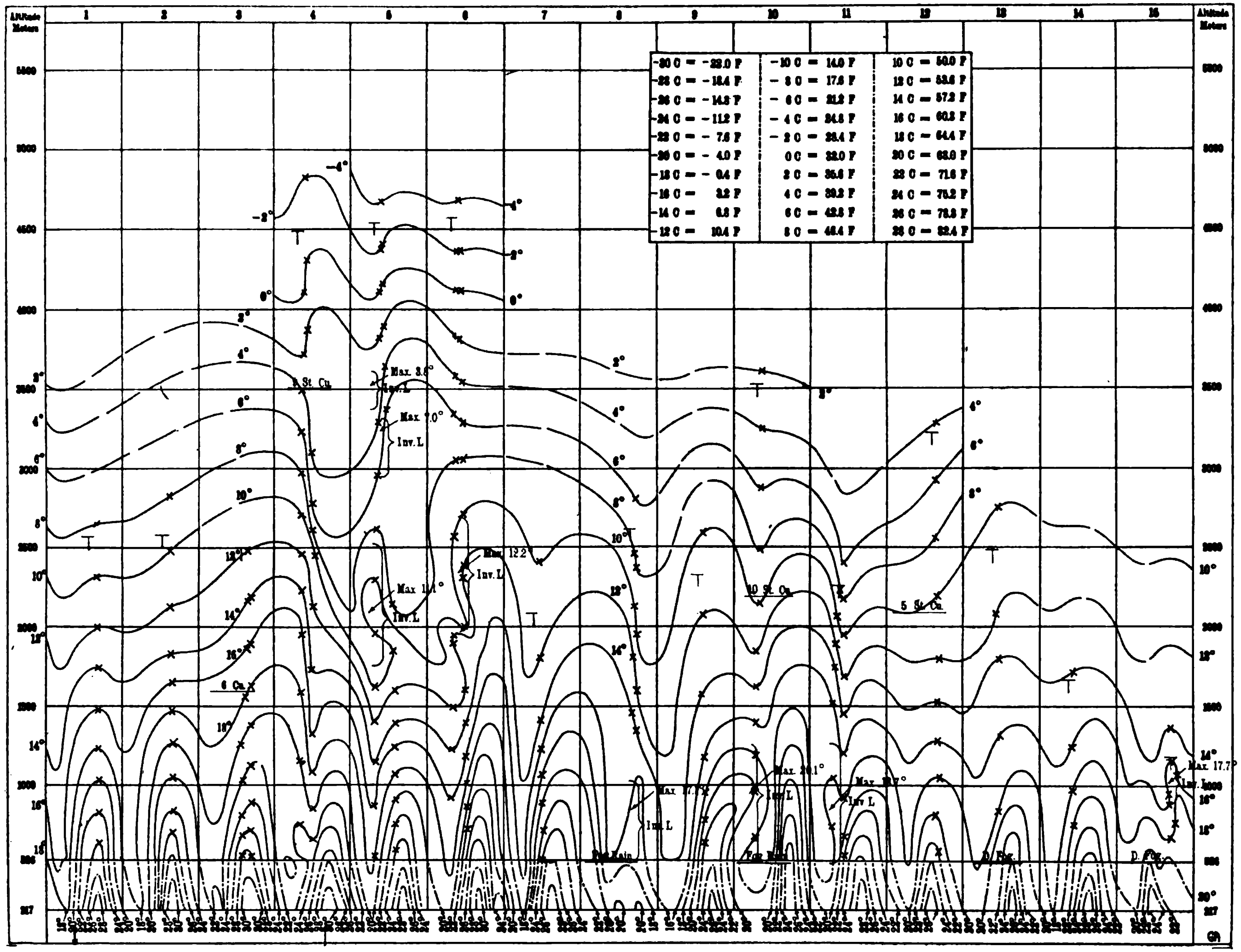


Free air isotherms, July 1–15, 1910.

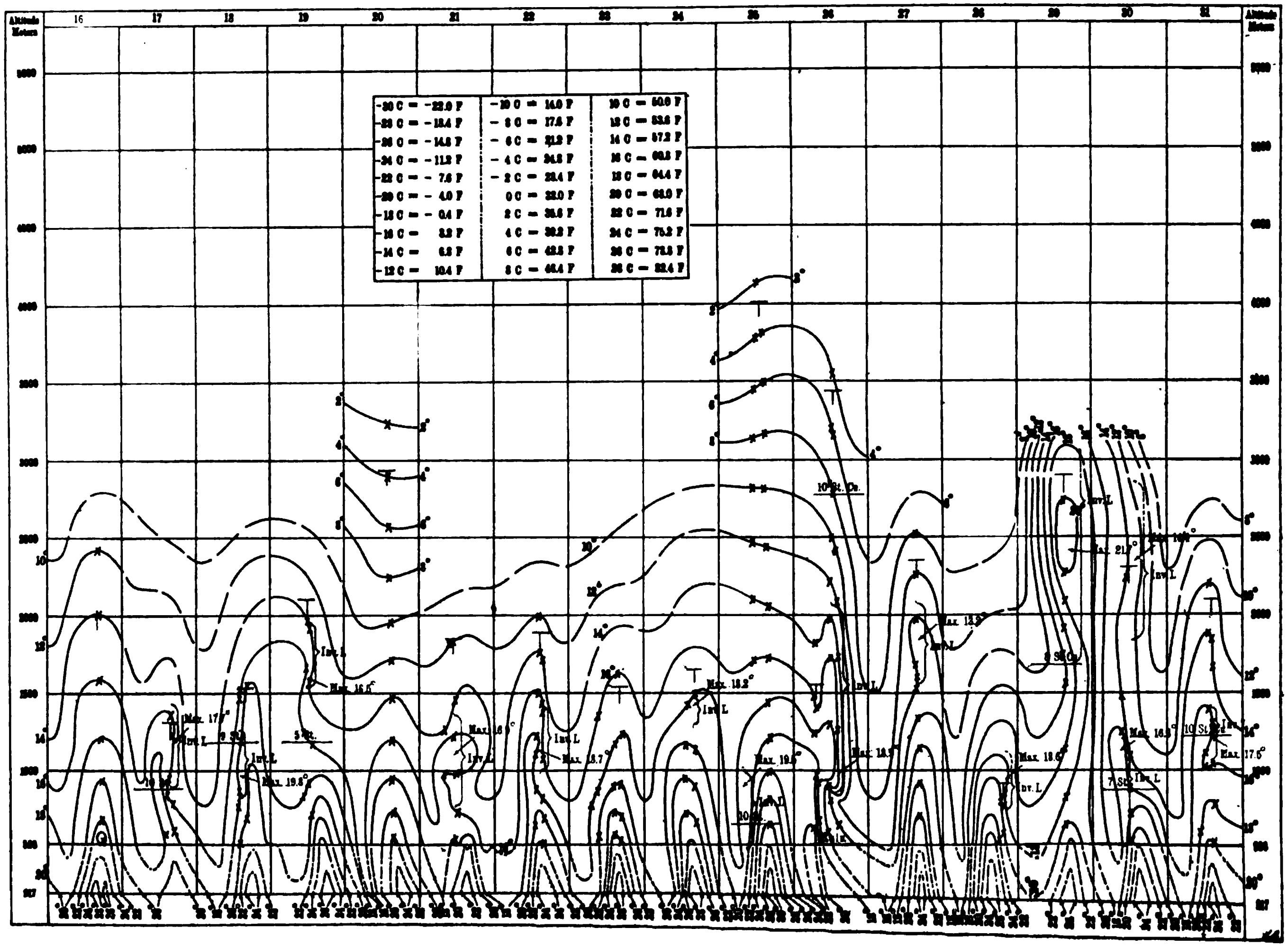


Free air isotherms, July 16-31, 1910.

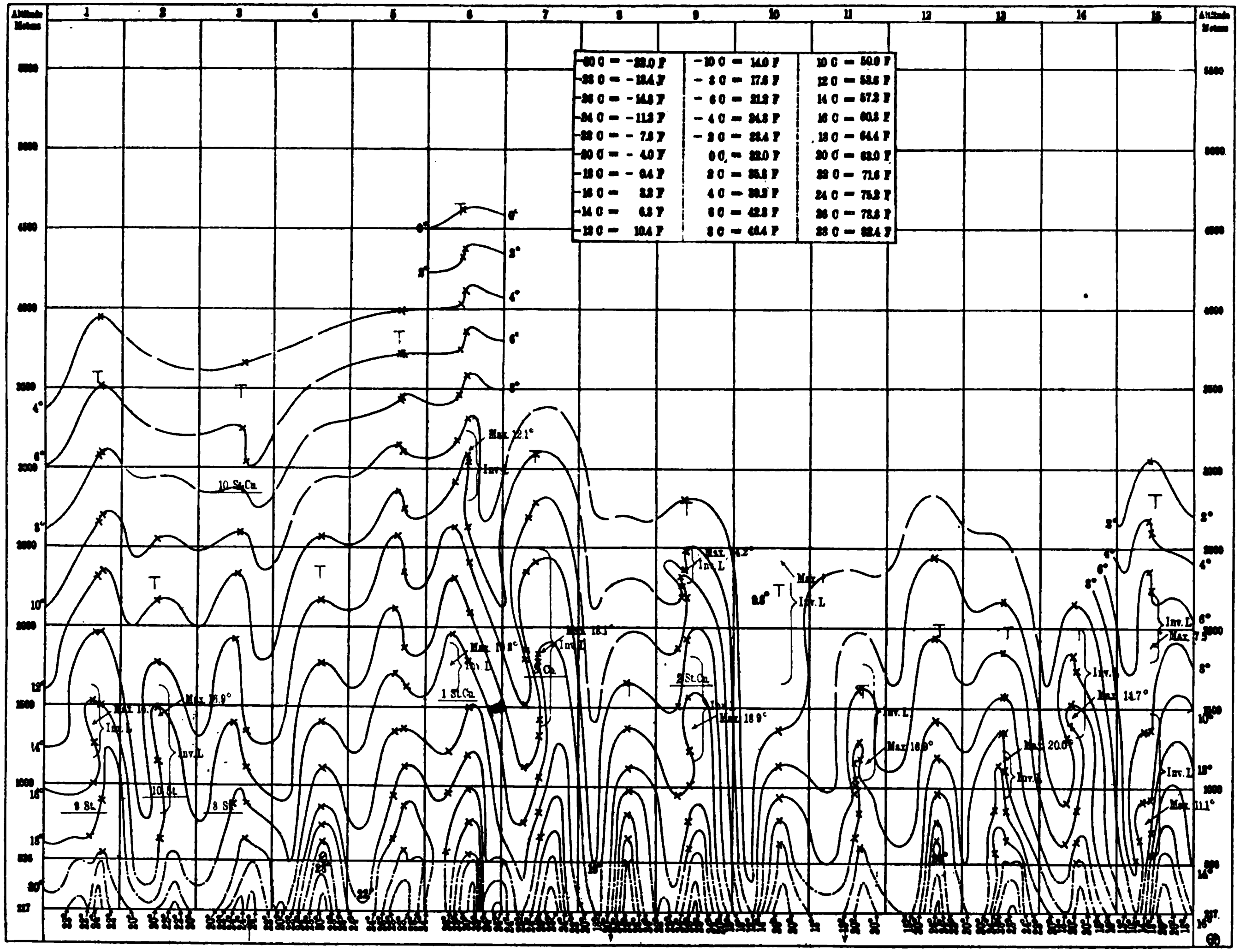
Chart XV.



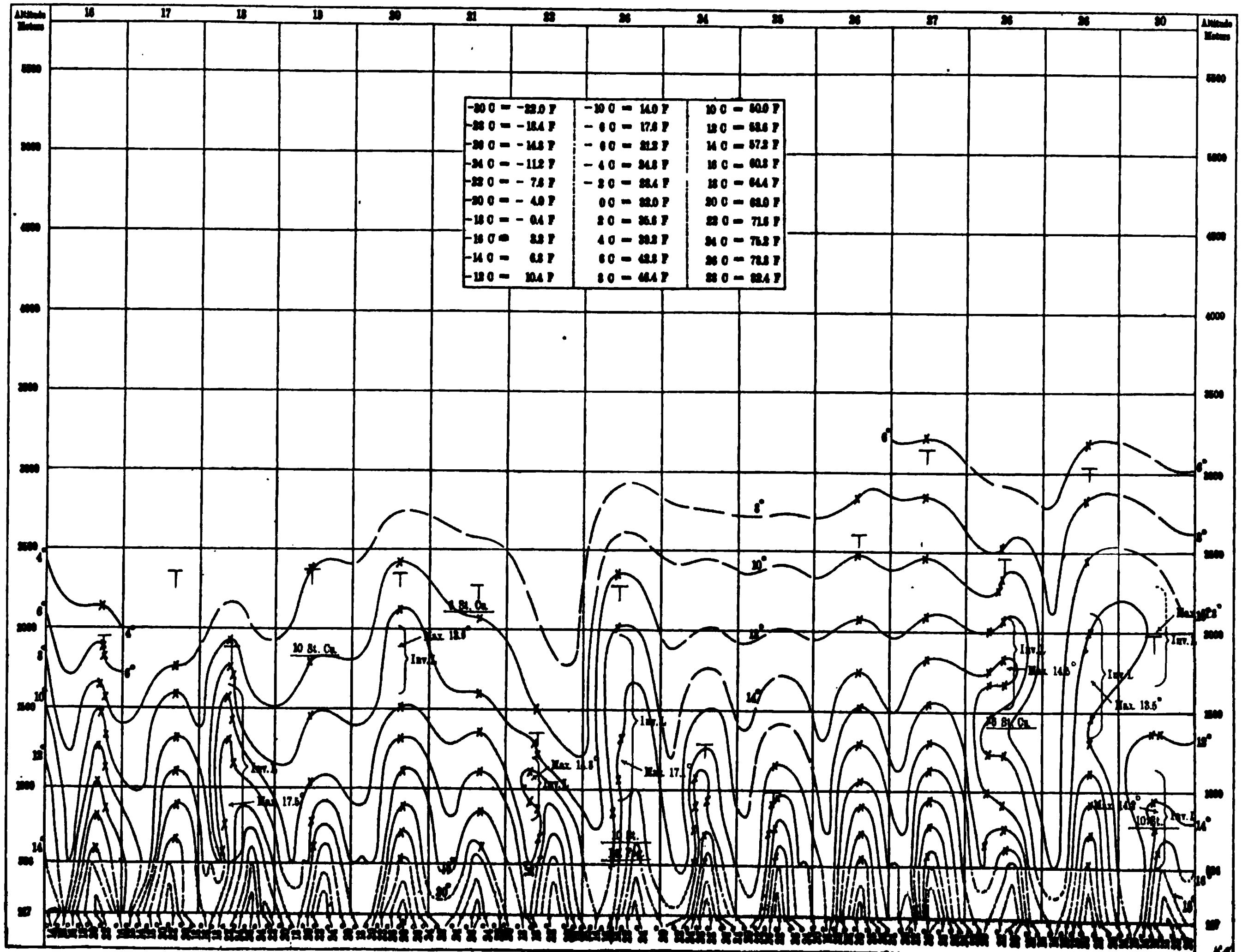
Free air isotherms, August 1–15, 1910.



Free air isotherms, August 16–31, 1910.



Free air isotherms, September 1-15, 1910.



Free air isotherms, September 16–30, 1910.

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Vol. 3 Part 5

BULLETIN

OF THE

MOUNT WEATHER OBSERVATORY

PREPARED UNDER THE DIRECTION OF
WILLIS L. MOORE, D. Sc., LL. D.
CHIEF U. S. WEATHER BUREAU

WASHINGTON
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1911

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(XVI) ON THE RELATION BETWEEN ATMOSPHERIC PRESSURE AND WIND.

By J. W. SANDSTRÖM.

(Presented May 11, 1910, to the Royal Swedish Academy of Science, and translated for publication in the Bulletin of the Mount Weather Observatory.)

1.

In the case of frictionless motion the relation between the distribution of atmospheric pressure and the velocity of the wind is very simple, since it depends principally on the geographic latitude.

Let ΔB represent the pressure gradient expressed in millimeters of mercury [1] for 1° of the meridian or geographic latitude, or 111 kilometers, G the acceleration, expressed in cm./sec.², produced by this gradient, v the velocity of the wind in meters per second, φ the geographic latitude, D the acceleration produced by the rotation of the earth, then we have at once,[2]

$$G = 0.093\ \Delta B \tag{1}$$
$$D = 0.0146\ v \sin \varphi \tag{2}$$

The acceleration G has the same direction as that of the pressure gradient. The acceleration D is perpendicular to the wind direction,

[1] Under standard gravity and temperature.—*C. A.*

[2] This formula for G holds good for 0° C. and 760 mm. For other temperatures and pressures we have

$$G = 0.093 \Delta B . \frac{T}{273} \cdot \frac{760}{b},$$

where T represents the absolute temperature [of the air] and b represents the atmospheric pressure in millimeters of mercury [at 0° C. and under standard force of gravity] and where we have neglected the aqueous vapor in the air since its influence on the density and velocity is very slight.

and in the Northern Hemisphere it is directed toward the right of this direction, but in the Southern Hemisphere toward the left.

In the case of uniform steady frictionless motion G and D hold each other in equilibrium; they are therefore of the same magnitude, but in opposite directions. In this case from equations (1) and (2) there results

$$\frac{v}{\Delta B}=\frac{6.37}{\sin \varphi} \tag{3}$$

that is to say, in such a case the velocity of the wind would be proportional to the pressure gradient.

Table 1 has been computed from equation (3), giving the ratio $v/\Delta B$ for every 10° of geographic latitude.

TABLE 1.

φ	$v/\Delta B$
10°	36. 6
20°	18. 6
30°	12. 7
40°	9. 9
50°	8. 3
60°	7. 4
70°	6. 8
80°	6. 5
90°	6. 4

Since D and G have opposite directions and D is perpendicular to the direction of the wind, therefore G is perpendicular to the direction of the wind. But G is also perpendicular to the isobars. Hence it follows that [under uniform steady frictionless conditions] the wind blows parallel to the isobars.

2.

The influence of friction on the motion of the wind has been especially studied by Guldberg and Mohn.[3] They assume that the [negative] acceleration R, which results from the friction, is proportional to the velocity of the wind and is opposite thereto in direction. Therefore they assume

$$R=\kappa v \tag{4}$$

where κ is called the coefficient of friction. According to these authors, therefore, the accelerating forces that act upon a particle of air

[3] C. M. Guldberg and H. Mohn, Études sur les mouvements de l'atmosphère. Christiania, 1880. [A translation is published by the Smithsonian Institution in Abbe's Mechanics of the Earth's Atmosphere, 1910.]

in the atmosphere are arranged somewhat as in fig. 1. In this figure the vectors G, D, and R have the significance above given. In the

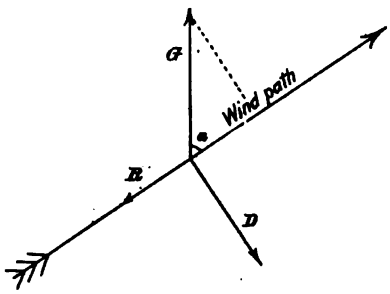


FIG. 1.—The influence of friction on the wind when all conditions are steady; according to Guldberg and Mohn.

case of uniform steady motion these three forces must be in equilibrium between themselves, and therefore G must have the same magnitude, but opposite direction, to the resultant of D and R. Hence there results

$$D = G \sin \alpha,$$
$$R = G \cos \alpha.$$

Moreover, if the C. G. S. system of units is used we have

$$D = 0.000\ 146\ v \sin \varphi$$
$$R = \kappa\ v,$$

therefore,

$$G \sin \alpha = 0.000\ 146\ v \sin \varphi,$$
$$G \cos \alpha = \kappa\ v;$$

by dividing these two latter formulæ there results,

$$\operatorname{tg} \alpha = \frac{0.000\ 146 \sin \varphi}{\kappa} \tag{5}$$

or,

$$\kappa = \frac{0.\ 000\ 146 \sin \varphi}{\operatorname{tg} \alpha} \tag{6}$$

By this formula (6), therefore,[4] the coefficient of friction κ may be computed from the inclination α of the wind direction to the direction of the gradient.

In this way Mohn found $\kappa = 0.000\ 0845$ for Norway; Loomis found $\kappa = 0.000\ 0803$ for North America; Clement Ley found $\kappa = 0.000\ 0254$

---

[4] This formula holds good for air moving steadily in a straight line. In the case of winds moving steadily in a curved path the centrifugal acceleration v^2/r must be considered; in this case we have

$$\kappa = \frac{0.000\ 146 \sin \varphi \pm v/r}{\tan \alpha}$$

where r is the radius of curvature of the wind path.

for the coasts, but $\kappa = 0.000\,0637$ for London, Oxford, Brussels, and Paris, and finally Mohn from the direction of the trade winds found $\kappa = 0.000\,0200$ for the Atlantic Ocean.

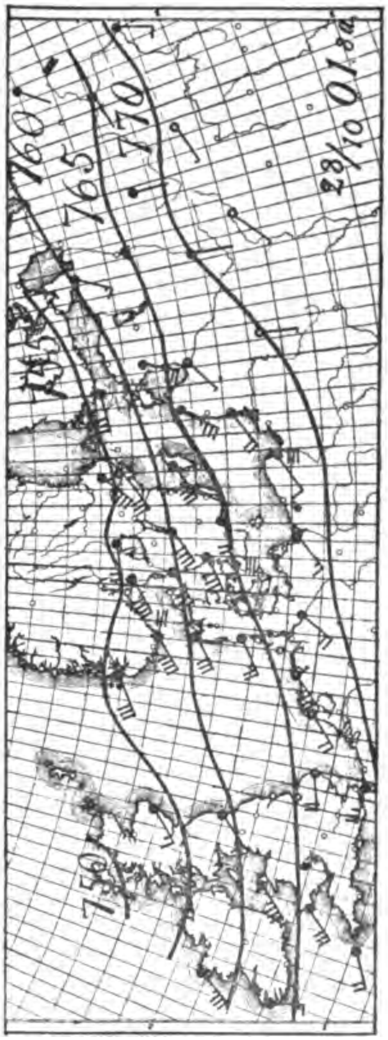


FIG. 2.—Synoptic weather chart for 8 a. m., October 28, 1901.

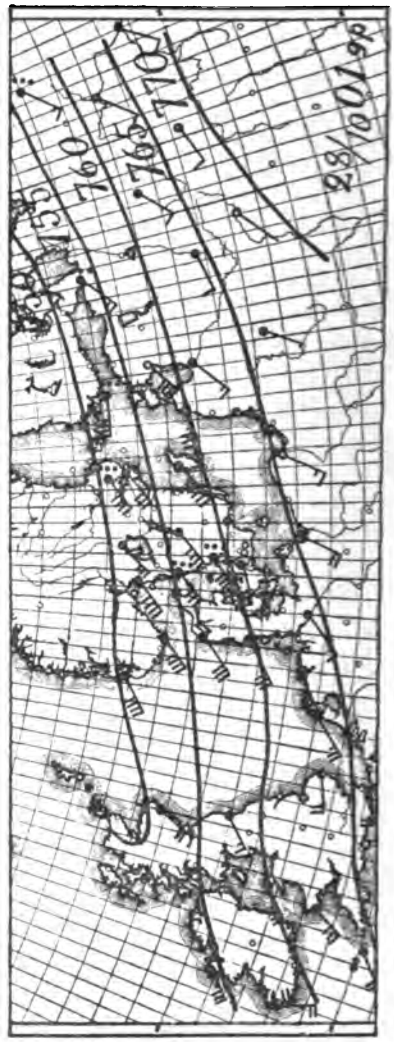


FIG. 3.—Synoptic weather chart for 9 p. m., October 28, 1901.

3.

In order to deduce the actual magnitude and relative positions of the three vectors G, D, R, we will consider a synoptic weather chart on which the isobars run parallel and straight and where the condition as to motion is as nearly steady as possible. Figs. 2, 3, and 4 present

such synoptic charts. In fig. 3 the isobars run very directly and regularly. From figs. 2 and 4 it is evident that a fairly steady condition prevailed during this time, since no great changes occurred

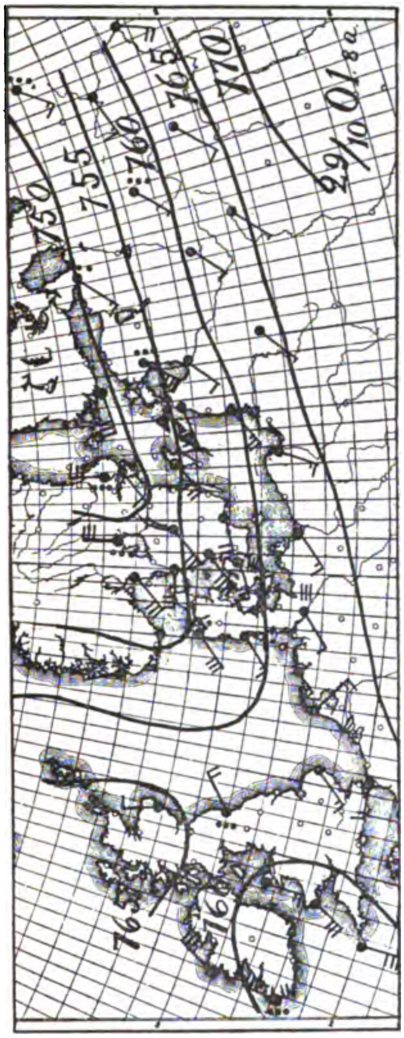


FIG. 4.—Synoptic weather chart for 8 a. m., October 29, 1901.

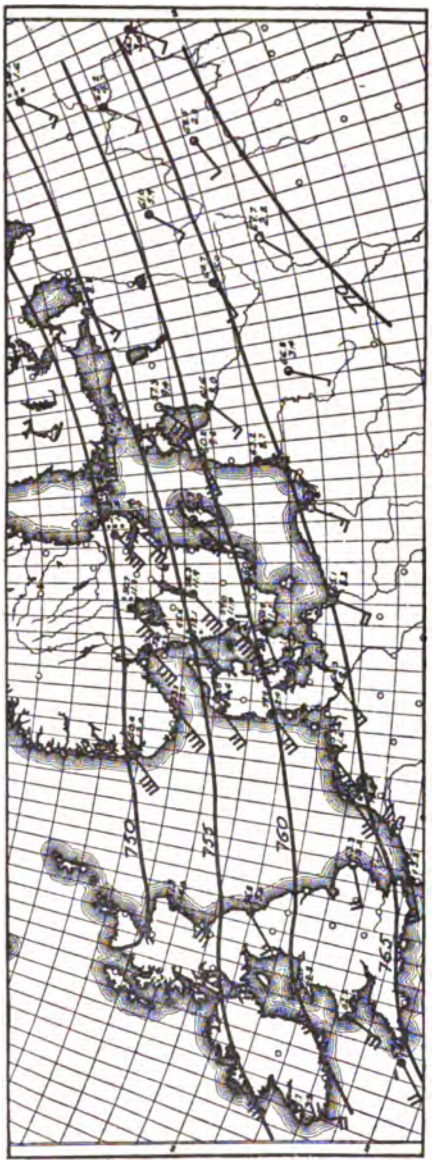


FIG. 5.—Synoptic weather chart for 9 p. m., October 28, 1901.

before or after the central chart. Now, on this chart we enter the accelerations G, D, and R, computed from the above formulæ (1),

(2), (4), and (6) for each station for which we have direct observations of the wind.

Fig. 5 shows this same chart, fig. 3, on a somewhat larger scale, and with added data. The estimated strength of the wind as here expressed on the Beaufort scale has been converted into meters per secbnd by the use of the following table, given at page 281 of the second edition of Hann's Lehrbuch der Meteorologie:

Beaufort scale.	Meters per sec.
1	1.7
2	3.1
3	4.8
4	6.7
5	8.8
6	10.7
7	12.9
8	15.4
9	18.0
10	21.0

According to measurements made on this chart the gradient of pressure, ΔB, amounts on the average to 2.58 millimeters of mercury per degree of a great circle, $v=8.8$ millimeters per second and $\alpha=57°$. The heavy lines on fig. 6 show the values of the respective vectors G, D, R, as computed in the above manner for each station on this chart, as also the observed wind arrows. The different vectors can easily be distinguished by the fact that G points north or northwestward, D is perpendicular to the direction of the wind, R is opposed to the direction of the wind and therefore is generally directed toward the southwest. The scale of the vectors is shown in the lower right-hand corner of fig. 6, up to 0.5 cm./sec.^{2} If the vectors are measured by this scale and averages are formed, then we find the following general values:

$$G=0.242 \text{ cm./sec.}^2,$$
$$D=0.108 \text{ cm./sec.}^2,$$
$$R=0.061 \text{ cm./sec.}^2.$$

In order to prove the correctness of the formulæ (1), (2), (4), and (6) we form the resultant of the three vectors G, D, and R for each station of the chart, fig. 6. By its method of construction it follows that this resultant must always lie in [or close to] the direction of the gradient G. It is, therefore, on fig. 6, drawn near G and parallel to it. Its average amount is 0.113 cm./sec.^{2} This acceleration [due essentially to the gradient] is equivalent to an increase in velocity in 24 hours, of 97.7 m./sec. But the synoptic chart, fig. 4, of the following day, October 29, 8 a. m., shows no such resulting velocities, but on

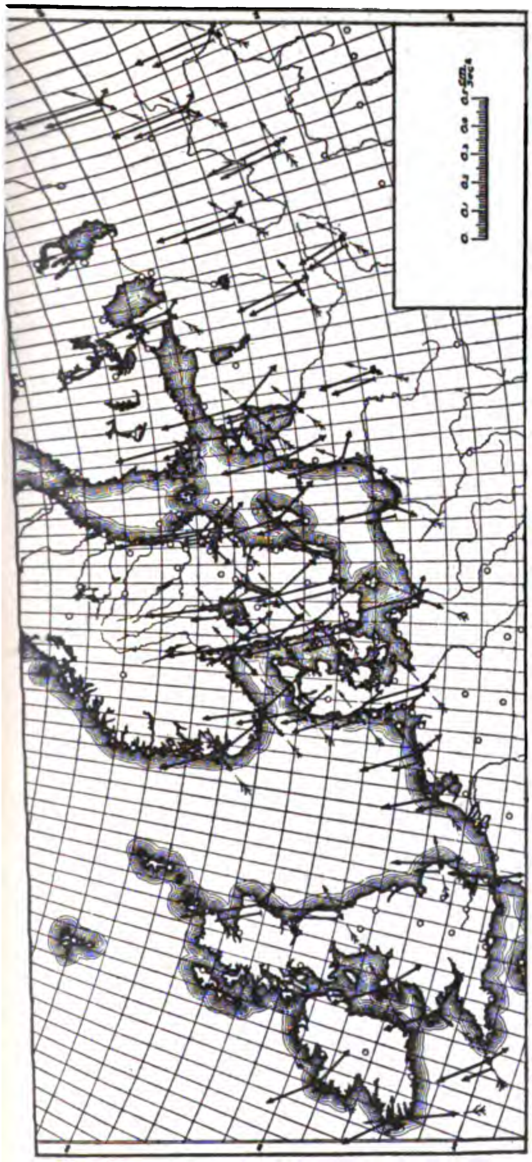


FIG. 6.—The Guldberg-Mohn accelerating forces, G, D, R, for 9 p. m., October 28, 1901.

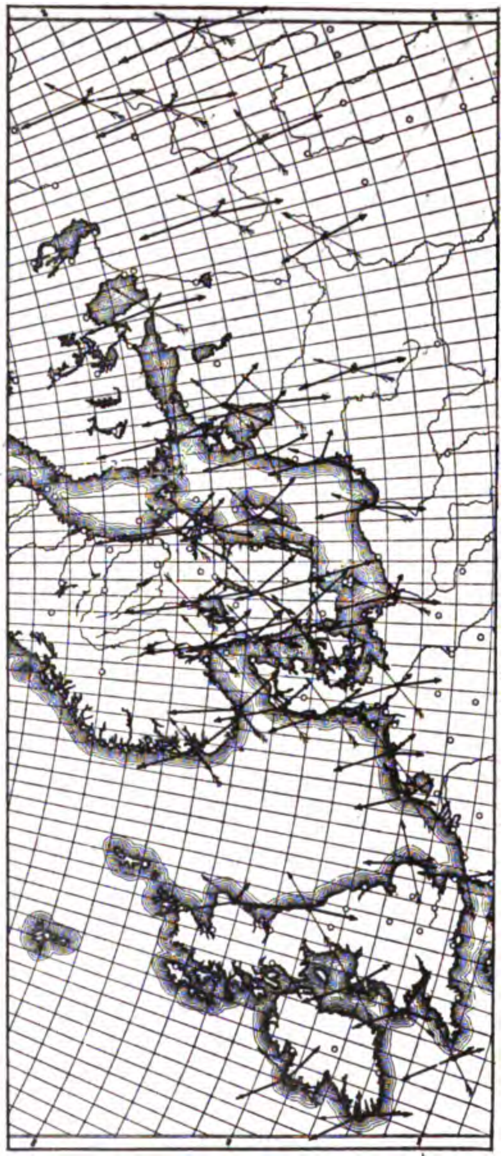


FIG. 8.—The Sandström accelerating forces, G, D, R, for 9 p. m., October 28, 1901.

the other hand only such as have remained very nearly unchanged. Hence it follows that at least one of the formulæ (1), (2), (4), or (6) must be erroneous. Now the formulæ (1) and (2) are based on strict mechanical principles and hence can not be in error, consequently the error must lie in either equation (4) or (6).

4.

Therefore formulæ (4) and (6) must be deduced anew, in order to find the error and to replace them by the correct equations. This problem is easily solved when we consider that the air is acted on by the three forces G, D, and R.

In the case of uniform, steady motion of the air these three forces [considered as steady accelerations, not as accumulated velocities] must be in equilibrium; that is to say, their resultant [acceleration] must equal zero. In this case therefore R must be of equal magnitude with the resultant of the vectors G and D, but have the opposite

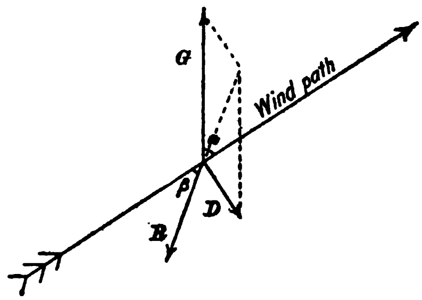


FIG. 7.—The influence of friction on the wind when all conditions are steady; according to Sandström.

direction [so that the resultant shall be zero and the motion be kept steady and uniform]. By this rule the direction and magnitude of the friction vector R is completely determined.

Fig. 7 shows how R is to be constructed graphically. Draw the vectors G and D, representing equations (1) and (2), complete their parallelogram, and draw the resultant of these vectors; R is of the same magnitude as this vector, but in the opposite direction.

If the angle between the direction of the vector R and the direction from which the observed wind comes is designated by β, then from fig. 7, combined with formula (2), there result the following relations:

$$\mathrm{tg}\beta = \mathrm{tg}\alpha - \frac{0.0146 \sin \varphi}{G \cos \alpha} \tag{7}$$

$$R = \frac{\cos \alpha}{\cos \beta} G \tag{8}$$

These formulæ (7) and (8) take the place of (4) and (6).

5.

Fig. 8 presents the synoptic chart on which these three vectors G, D, and R [for steady winds] are inserted. The vectors G and D are the same as those in fig. 6, but, on the other hand, R is constructed according to the rule just given; R is easily recognized by the fact that it is always directed toward the south.

It is evident from the chart that R is not directed exactly opposite the wind, but has a deviation β toward the right. This deviation, according to the measurements on the chart, amounts on the average to 38°. The average value of R is 0.166 cm./sec.^{2} and is therefore 2.7 times larger than the erroneous value previously computed for this quantity.

This last chart, fig. 8, allows us to draw certain conclusions as to the influence of friction on the motion of the air. First, it is evident that the accelerating force R_e, that acts on the air in consequence of friction on the earth's surface is [and must be] directed opposite to

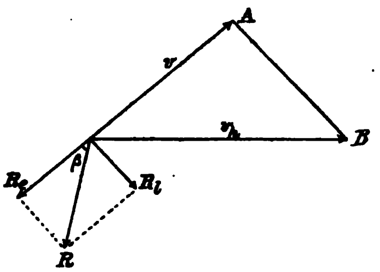


FIG. 9.—The components of R, the retarding acceleration of friction, under steady conditions; according to Sandström.

the direction of the wind. Therefore, the angle of deviation β of the vector R, to the right of the direction of the wind, shows us that the motion of the air is influenced not only by friction against the surface of the earth, but also by a friction of another sort. This can only be the friction on the air that lies above the air that is found near the earth's surface; the accelerative force R_l that originates from this cause must depend on the movement of this upper air relative to the lower air near the earth's surface.

In fig. 9 let the arrow v represent the direction and velocity of the movement of the air in the neighborhood of the earth's surface and v_h the direction and velocity of the higher air; then the direction and length of the line AB represents the velocity of the upper air relative to the air in the neighborhood of the earth's surface. The accelerative force R_l must have the same direction, and must be directed from A to B.

This elementary derivation of the force R_l can, however, only give an approximately correct value. In order to be able to obtain an accurate determination of this quantity, we must consider the movement of the intermediate layer of air, for in general the atmospheric movement veers not suddenly, but gradually, to the right as the altitude increases. Therefore the exact determination of R_l would demand observations of the wind at every point of a vertical line, and then a discussion of these observations, based on the hydrodynamic equations of motion, in a manner analogous to that used when studying the acceleration produced by friction in streams in which the particles move in rectilinear and parallel paths. But just as in these streams one can deduce an approximate value of the frictional acceleration from the relative velocities of particles that are at finite distances from each other, but still not too far apart, so also in the present case we can deduce an approximate value of this retardation, or the negative acceleration due to friction, from the relative velocities of particles of air that are at finite distance apart.

In fig. 9 let the vector R_e represent the accelerating force R_e resulting from the friction over the surface of the earth; then we find the value of R, or the total frictional resistance of the wind due to the ground below, R_e, and to the air currents above, R_l, by constructing the parallelogram of the vectors R_e and R_l, as shown in fig. 9. This shows the character of R as depending on two different sources of frictional resistance.

6.

We must consider G as the primary or fundamental one of the three accelerating forces G, D, and R, since D and R can not exist until the air is first set in motion by G. In calm air D and R are equal to zero, and therefore of themselves have no power to set such calm air in motion; it is only G that is able to do this.

It is therefore helpful to determine the ratios of the vectors D, R, and v relative to G. The following values result from the average quantities above given.

[Sandström's deductions from the weather map for 9 p. m. October 28, 1901, for latitude $\varphi = 63°$ N., adopting Hann's table for the conversion of Beaufort's wind scale into meters per second, assuming that the wind is resisted by the frictional resistance of the ground below and the layers of air above, and assuming that this map presents a case of steady rectilinear winds.—*C. A.*]

$$\alpha = 57°$$

$$\operatorname{tang} \beta = \operatorname{tang} \alpha - 0.0146 \frac{v}{G} \frac{\sin \varphi}{\cos \alpha}$$

$$\beta = 38° \text{ and } \varphi = 63°$$

$$\frac{D}{G} = \frac{0.0146\, v \sin \varphi}{0.093\, \Delta B} = \frac{0.0146 \times 8.8 \sin \varphi}{0.093 \times 2.58} = 0.45$$

$$\frac{R}{G} = \frac{\cos \alpha}{\cos \beta} = 0.69$$

$$\frac{v}{G} = \frac{8.8}{0.093 \times 2.58} = 37$$

In the following paragraphs these values are preliminarily assumed as approximate normal values for northern Europe, and they have been followed in drawing fig. 7, which therefore represents their relative magnitudes and positions.

7.

If the three accelerating forces, G, D, and R are in equilibrium, then the motion of the air is rectilinear and uniform. If, on the contrary, these have an appreciable resultant A, then the motion is accelerated and the acceleration is the force A. In general A is very small compared with G, D, and R. If a stormwind of 20 meters per second develop within 24 hours in calm air, then it is necessary that the acceleration be only $A = 0.023$ cm./sec.^{2}, or only 10 per cent of the above found average value of G, and only 14 per cent of the above value of R. Hence we easily see how small is the error that arises when R is deduced under the assumption that $A = 0$, from synoptic weather charts of regions where the movement of the air has the greatest possible uniformity. Still, in exceptional cases and for short periods of time, A can attain a larger value, especially when a storm quickly develops in a short time, or when the movement of the air is affected by periodical oscillations. Such cases are easy to recognize and should be avoided in the determinations of R.

8.

We are now in a position to deduce the atmospheric movements that will be produced by the forces above considered. For the sake of simplicity we assume that at the beginning the air is perfectly still and that no forces are acting on it, so that G, D, and R are, respectively, zero. If now there begins a change in the distribution of atmospheric pressure, so that there arises a barometric pressure

gradient ΔB, then there is immediately developed an accelerating force $G = 0.093 \Delta B$ in the direction of the gradient.

The actual initial acceleration of the air is thus equal to G, because at the beginning both D and R were zero. But the air is gradually set in motion in the direction of the gradient, by the accelerative force G. This motion evokes the forces D and R, which deflect the paths of the winds to the right of the direction of the pressure gradients. These forces D and R steadily increase until they are in equilibrium with G. In this process A gradually diminishes and finally disappears entirely, so that the motion of the air becomes uniform.

The phenomena proceed as just described when the path of the wind is not affected by the inertia of the atmosphere. This inertia tends to make the wind move in paths as straight as possible. The consequence is that the direction of [a sinuous] wind does not coincide exactly with that of the resultant A of the forces G, D, and R, but is always deflected from A toward the convex side of the path of the wind. Thus, instead of a uniform rectilinear motion there arises an oscillatory movement, as is better shown in fig. 10. Let the curved line OC in fig. 10 be the path described by a particle of air. Assume this particle to have been originally standing still at the point O, then let it be set in motion by G, and subsequently be deflected to the right by the forces D and R, that result from this motion itself. At the beginning of its movement and because of the inertia of the particle of air, its motion will be in a straight line, that is to say, it will not be deflected to the right so much as it ought to be. Therefore the particles of air will be too much accelerated by the pressure gradient whereby its velocity becomes too great, and D and R will increase until their resultant prevails over G. This condition is represented at point No. 1 in the path OC in fig. 10.

At this point, No. 1, the resultant A of the accelerative forces G, D, and R pushes toward the right and the path of the air is therefore deflected still more strongly toward the right, so that indeed α may exceed 90°. This new condition is represented at point No. 2 of the path in fig. 10.

But now A acts backward along the path, so that the velocity of the particle of air rapidly diminishes. But for this latter reason D and R also diminish, so that eventually G becomes the controlling influence. This stage is represented graphically at the point No. 3 in the path.

At the latter point A is directed to the left and therefore the path is also curved to the left, that is to say, α diminishes so that it becomes very small. This is shown at point No. 4 of the path OC in fig. 10.

Here A acts in the forward direction, wherefore the velocity of the particle of air increases rapidly. But this causes D and R to increase so much that their resultant overpowers G. This is shown at point No. 5 of fig. 10. The condition at point No. 5 is identical with that at point No. 1 and the further development has the same result as before, so that the movement of the air becomes oscillatory [or sinuous].

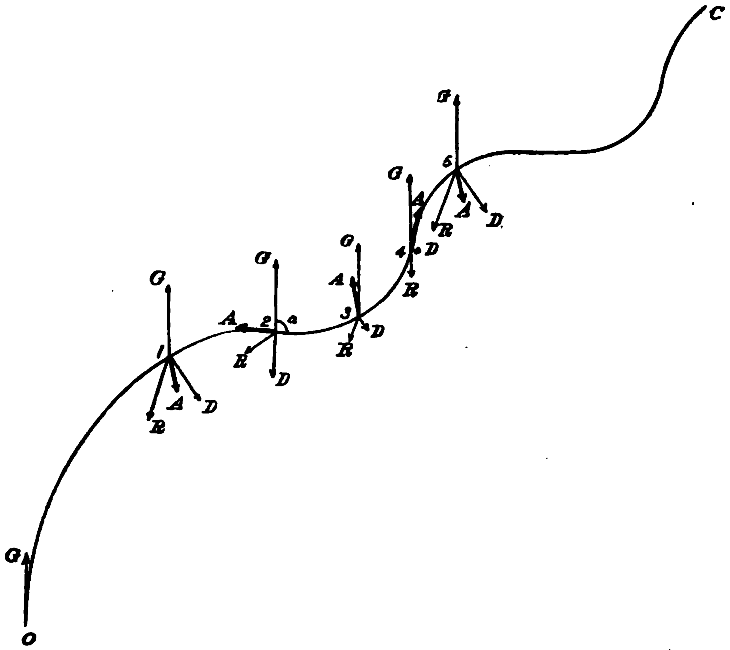


FIG. 10.—Oscillatory movement of the air.

When we consider A more closely we find that, in oscillatory movements of the air, A revolves like the hands of a clock. This rule holds good in the Northern Hemisphere. For oscillatory motion in the Southern Hemisphere A turns in the opposite direction.

9.

From Fig. 10 it follows that in oscillatory movements of the air the deflection α is subject to great variations. If therefore such variations occur on a synoptic weather chart, such as are easily recognized by the irregular distribution of the wind directions, then this is a fairly safe indication that the movement of the air is oscillatory.

Fig. 11 presents a synoptic chart where, at the first glance, the wind arrows appear very irregular. On the other hand the paths of the wind for these wind arrows, which are given in fig. 12, appear as a regular system of well developed sine lines. Hence the synoptic chart, fig. 11, represents an oscillatory movement of the air.

Fig. 13 contains the deflection α, expressed in angular degrees according to measurements on the synoptic chart fig. 11. The lines

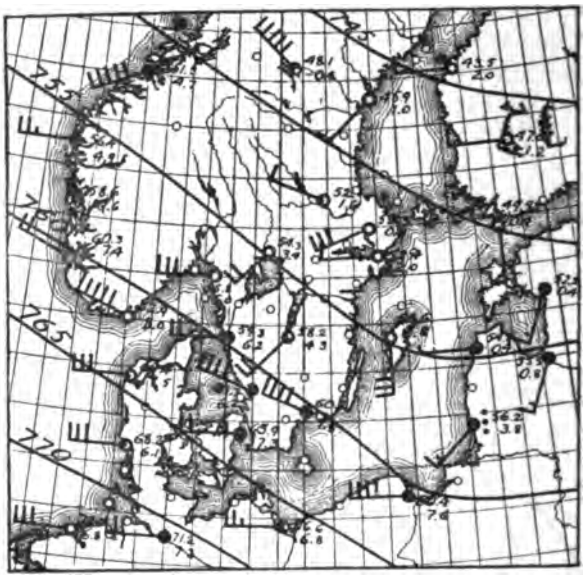


FIG. 11.—Synoptic weather chart for 9 p. m., January 7, 1902.

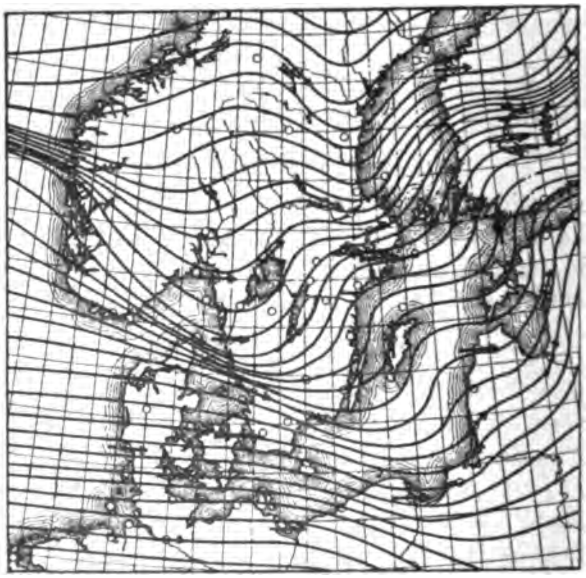


FIG. 12.—Wind paths for 9 p. m., January 7, 1902.

drawn on fig. 13 are lines of equal deflection α and are drawn for every 22.5°. It is evident that these lines of equal deflection assume

a characteristic elongated form, in case the air has an oscillatory motion. This becomes evident also when we draw lines of equal

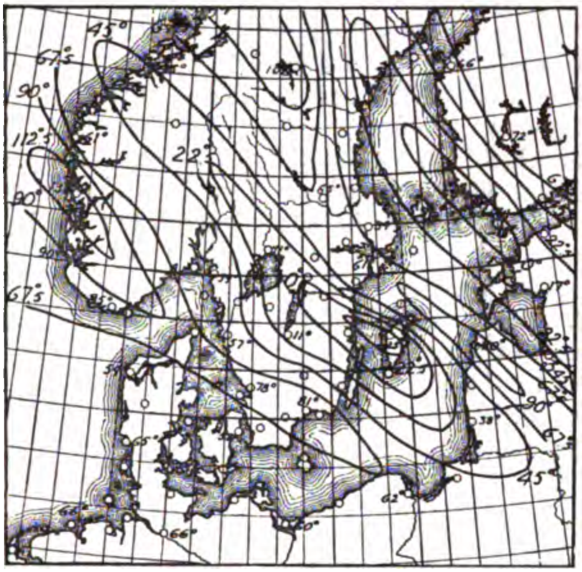


FIG. 13.—Lines of equal inclination (a) of the winds to the local gradients at 9 p. m., January 7, 1902.

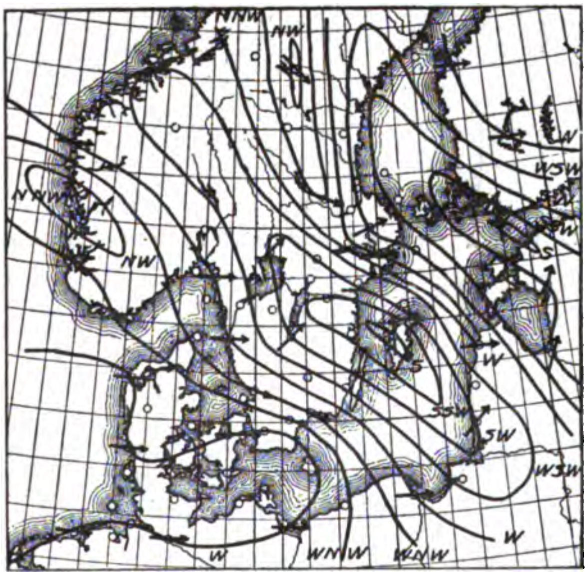
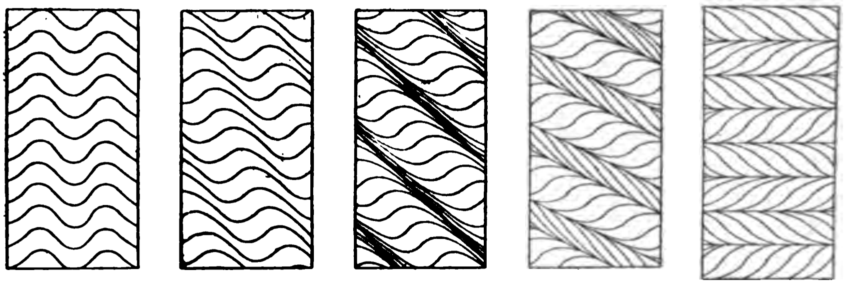


FIG. 14.—Lines of the same direction or isogonics of the winds at 9 p. m. January 7, 1902.

wind direction (isogones), as is done in fig. 14, instead of lines of equal deflection. In order to draw such lines we have only to connect

together the stations at which the observed wind directions are alike. In the following text we will designate these lines that have identical wind directions as isogonic lines, or isogonics.

When the isogonics cross the mean wind direction nearly at right angles, as occurs in the case now being considered, then the paths of the wind assume sinusoidal curves, as shown in fig. 12. But the isogonics may cross the average wind direction slant-wise, or may even coincide with the wind direction. In such cases figs. 15, 16, 17, 18, and 19 show the movements of the air. In each of these five figures the mean wind direction is horizontal, but the isogonics are, respectively, inclined thereto by the angles 90°, 67.5°, 45°, 22.5°, and 0°. The first of these, fig. 15, shows wind paths of the same form as in fig. 12. In the second of these, fig. 16, these paths are successively pushed to the right, relatively to each other. In fig. 17 this transposition to the right has been pushed so far that there arise dividing lines between the wind paths, and in fig. 18 there is formed a split, or separation, between these dividing lines, which persists [5] even in fig. 19.



15 16 17 18 19

FIGS. 15-19.—Different types of wind paths for oscillatory motions of the atmosphere.

The atmospheric movements recorded on the synoptic weather charts very often give rise to these forms of wind paths. Fig. 20 presents a synoptic chart on which the isogonic lines are drawn in addition to the data for pressure, temperature, wind, and cloudiness. Here we see the isogonics inclined slant-wise to the wind; the corresponding wind paths are shown in fig. 21. These resemble those of fig. 16. Fig. 22 gives a synoptic weather chart where the isogonics almost coincide with the mean wind direction. Fig. 23 contains the

[5] The graphic construction of these wind paths is treated of in detail in my memoir "On the motions of fluids." Annalen der Hydrographie u. maritimen Meteorologie. June, 1909.

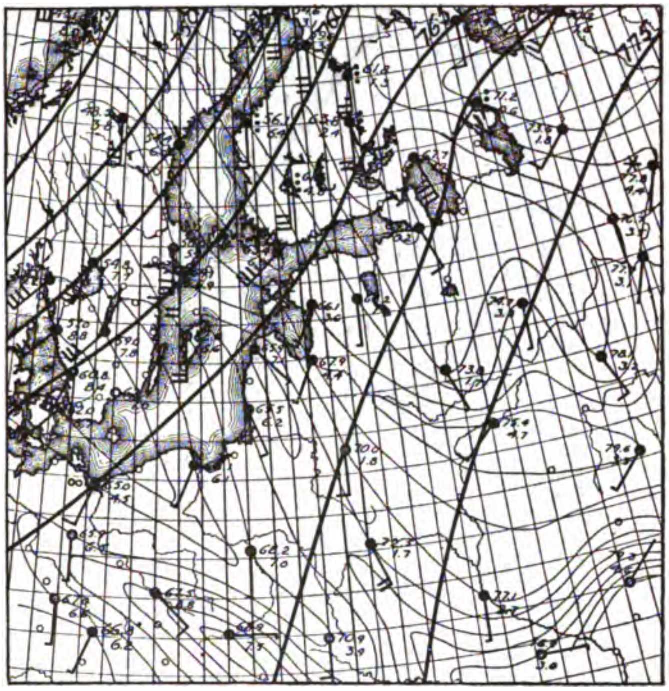


FIG. 20.—Synoptic weather chart for 9 p. m., November 8, 1900, with its isogonic lines.

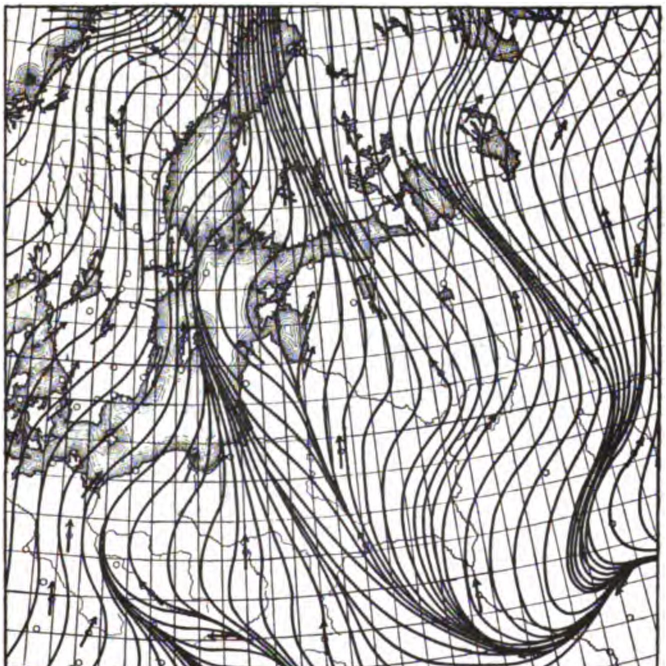


FIG. 21.—Wind paths for 9 p. m., November 8, 1900.

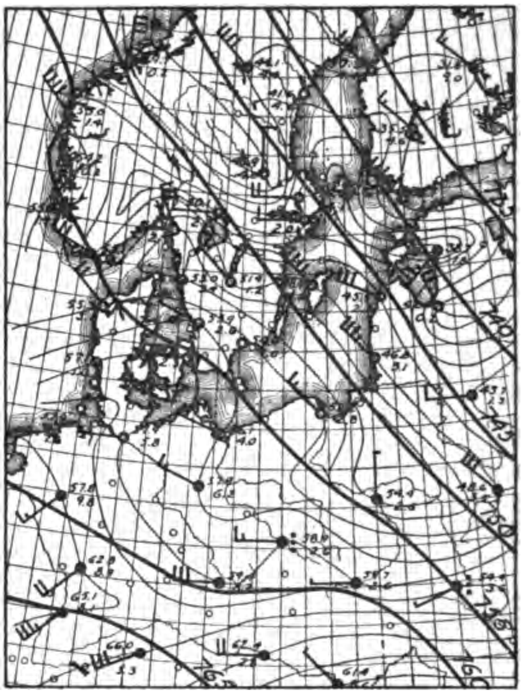


FIG. 22.—Synoptic weather chart for 9 p. m., November 20, 1901, with its isogonic lines.

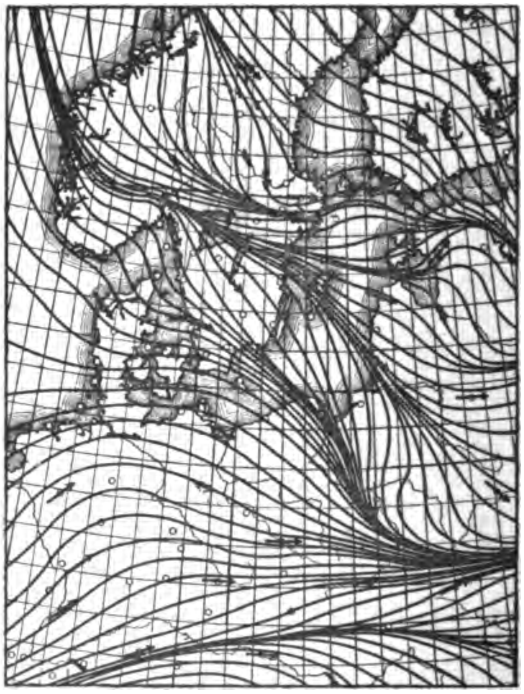


FIG. 23.—Wind paths for 9 p. m., November 20, 1901.

wind paths corresponding to fig. 22, which we perceive are similar to those of fig. 18.

All synoptic weather charts, whose wind paths resemble any one of the figs. 15–19, represent or imply oscillatory movements of the air.

10.

Oscillatory movements of the air can be produced by any disturbance in the three fields of force G, D, and R; for instance, by local increase or diminution of the friction, as when the air flows over a variety of topographic features, or by rapid variation in the distribution of atmospheric pressure, etc. A glance at fig. 10 shows that such disturbances do produce oscillations.

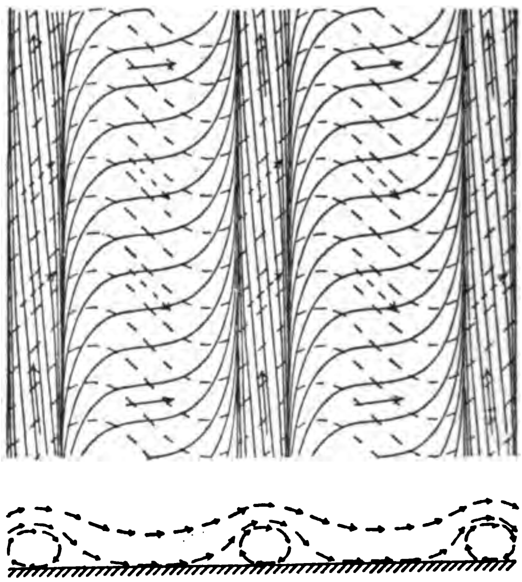
According to figs. 15–19 the air paths that characterize oscillatory movements in the atmosphere can assume two different forms. They are either sinusoidal lines, similar to each other as seen in figs. 15 and 16, or they have a point of inflection resembling the sign of integration ($\int$)[6] as shown in figs. 18–19. We shall scarcely find on the synoptic charts anything corresponding to fig. 17, since this intermediate form occurs only momentarily at the instant of transition from a path of one form to that of another; it is therefore very unstable.

Now, at the first glance on the figs. 15–19, these two kinds of oscillatory movements appear very different from each other, but a closer study shows that they are closely related and that indeed, under some conditions, either form presupposes the presence of the other forms. Fig. 24 presents such a case; in this figure the dash lines are the sinusoidal paths of the winds of an upper stratum of air that is in the act of oscillatory motion. Now, the direction of the wind at the surface of the earth differs from that above the surface, for it is well known that in the lower portion of the atmosphere the wind deviates to the right with increasing altitude. If we assume that the angular difference of the direction of motion of the upper air, relative to that of the earth's surface, amounts to 50° and draw the paths of the winds at the earth's surface under this assumption we shall obtain the full lines shown in fig. 24. These wind paths have the shape of the sign of integration and have lines of separation or discontinuity. To some extent they resemble the wind paths of the chart, fig. 23, and therefore are probably only a phenomenon accompanying every regular sinusoidal oscillation in some higher stratum of air. Without further explanation it is now evident how

[6] The integration symbol $\int$ has one point of inflexion and is a flexuous curve.—*C. A.*

the individual particles of air move in the case of oscillatory movements of the atmosphere, when the wind paths have sinusoidal forms. But the matter is more difficult when the wind paths assume the flexuous form ($\int$) of the sign of integration, and when at the same time also lines of dissociation appear among them.

In figs. 18 and 19 we can perceive two different kinds of lines of dissociation, namely, those in which the air flows from both sides inward toward the line of separation, and those in which the air flows on both sides outward from this line.



Oscillatory movements of the atmosphere.

FIG. 24.—Horizontal projection.
FIG. 25.—Vertical section.

These lines of discontinuity will be called, respectively, *lines of inflow* and *lines of outflow*, or lines of contracting and lines of broadening, or lines of convergence and divergence. As is evident from figs. 15 to 19, and 24, and the synoptic chart, fig. 23, these lines of inflow and outflow always occur alternately, so that two lines of the same name never occur next to each other. Now in the lines of convergence the air must rise and in the lines of divergence it must sink. Therefore the air must execute a vertical oscillation. In this movement probably some of the regions between the lines of discontinuity serve to some extent as rollers for the air flowing over

them, as is indicated in the small fig. 25, below fig. 24. This fig. 25 represents the probable motion of the air from left to right in a vertical section directly across fig. 24.

Probably the weather is very little affected by the oscillations of the air; for the horizontal oscillations can play no part in the weather, and the vertical oscillations have amplitudes too slight to produce notable effects. Possibly a closer investigation might show a larger cloudiness over the regions where the wind at the earth's surface is most decidedly deflected to the left; for it follows from fig. 25 that the air rises highest in the regions of vertical oscillations.

11.

The movements of the air hitherto considered are those produced by parallel equidistant isobars, and the examples and charts have been so chosen that the isobars are only slightly curved and are as nearly equidistant as possible.

But in general isobars are curved in very complex styles. Therefore it is important for us to deal with those movements of the atmosphere that occur in connection with curved isobars.

The isobars shown on synoptic weather charts represent lines of intersection between the level surface of the ocean and the isobaric surfaces that permeate the atmosphere. These surfaces intersect under extremely acute angles. Geometry teaches that under such conditions the intersection of two systems of surfaces must more or less resemble curves of the second degree. This also is confirmed by experience; for instance, nearly all the lines occurring in the 114 most common types of isobars in north and west Europe, as collected by Prof. H. H. Hildebrandsson,[7] can be considered as parts of circles, ellipses, parabolas, or hyberbolas.

All lines of the second degree are characterized by the fact that they have no point of inflection. Therefore, if on any synoptic weather chart we connect the inflection points of the isobars, then the chart will thus be divided into large regions within which there are no inflection points, and thus the isobars assume to a high degree the appearance of lines of the second degree. Such a region will be called an *isobaric region of the second degree* in contrast with the rectilinear isobaric system previously considered, which we will now designate as an *isobaric region of the first degree.*

When the isobars within such an isobaric region are not perfectly circular they must have a maximum curvature at some special point. If

[7] See H. H. Hildebrandsson, Typer för synoptiska väderlekskartor. Akademiska bokhandeln. Upsala.

these points of maximum curvature are connected together we thus draw a line that may be designated as the axis of the isobars. The direction of such an isobaric axis will always be reckoned as being toward the concave side of the isobars. For instance, in a system of elliptical isobars there are two isobaric axes, both of which coincide with the major axis of the ellipse and are directed toward the center of the ellipse. Figs. 26 and 27 represent two systems of isobars resembling parabolas, with the corresponding wind paths constructed under the assumption that the deflection of the winds from the gradient is $\alpha = 57°$, as in §6 and §8, fig. 10. In fig. 26, the axis of the isobars is

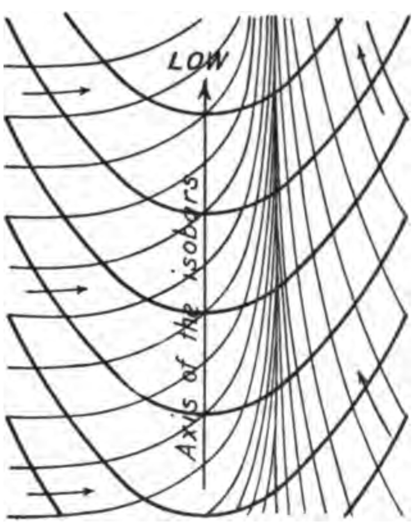


FIG. 26.—Motion of the atmosphere when the isobars are parabolic.

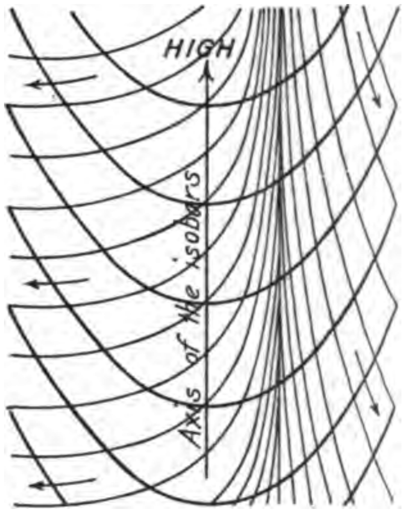


FIG. 27.—Motion of the atmosphere when the isobars are parabolic.

directed toward the low pressure, and on the right-hand side of this axis the air flows toward a line of convergence. Since there is no neighboring line of divergence that could compensate for this convergence, therefore there must result a considerable ascent of air in the neighborhood of this line of convergence, and as is well known this ascension produces bad weather. Hence we have the following important rule:

When the axis of isobars is directed toward low pressure, there is bad weather on the right-hand side of this axis.

On the other hand in the second isobaric system, or fig. 27, the axis of the isobars is directed toward a region of high pressure. On the

right-hand side of this axis there is a line of divergence from which the air flows outward on either side. Hence the air in this region must sink and therefore the weather must be clear; hence we draw the following rule:

When the axis of isobars is directed toward a high pressure, there is clear weather on the right-hand side of this axis.

These two rules hold good for the Southern Hemisphere also, but with this difference, that we must substitute the word left for right.

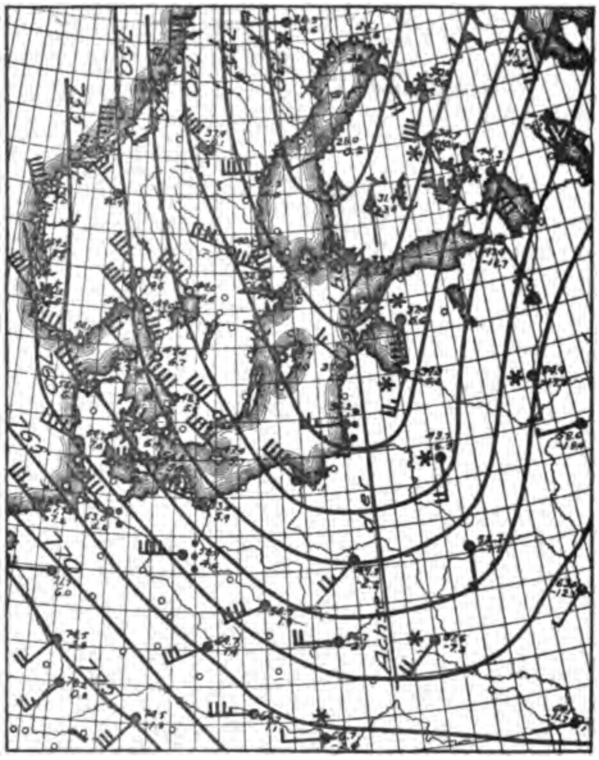


FIG. 28.—Synoptic weather chart for 8 a. m., January 16, 1902, with its isobaric axis.

The chart, fig. 28, a synoptic chart for January 16, 1902, contains parabolic isobars and shows the axis of these isobars as directed toward low pressure. Hence the first of the two rules above given applies to it, and the chart clearly shows that the weather on the left of the axis is generally clear, but on the right is generally bad.

12.

In order to obtain an unobjectionable deduction of the relation between the wind and the distribution of atmospheric pressure it is necessary to exclude all other circumstances that may influence the formation of the wind and its further course, so that these can not make the result misleading. In this matter of course the distribution of density is of primary importance. Its influence on the motion of the air was first explained in Bjerknes theory [8] of circulation. This influence is quite important and under some circumstances can wholly upset the relations between pressure distribution and wind. Thus, for instance, in thunderstorm gusts with slight gradients of pressure, to which correspond only moderate winds, there may occur hurricane phenomena which evidently owe their origin to the distribution of density.

In order to form a clear idea as to the order of magnitude and method of action of this influence of the distribution of density, we will consider more closely the thunderstorm gust of October 4, 1908. The isochrones of this gust are shown in fig. 29. As is seen from this chart it results that the thunderstorm began about 11 a. m. in northwest Dalarna, in Sweden, and traveled with a nearly rectilinear front toward the south-southeast at an average rate of 64 kilometers per hour and ended about 8 p. m. in Gotland. The chart, fig. 30, shows the wind directions and wind paths of this gust for 2 p. m. of October 4. On this chart is visible a heavy line of convergence drawn parallel to the isochrones of fig. 29. A comparison of the two charts shows that this line of convergence of the winds precedes the front line of the thunderstorm at a distance of about 150 kilometers. Hence, the first sign of the approach of a thunderstorm is a change in the direction of the wind that indicates the passage of the line of convergence. This change of wind was noted by many observers.

After this change of wind the sky first became overcast with coal-black clouds and, at the same time, the temperature of the air fell by as much as 4° to 6° centigrade. Then the wind increased to the strength of a hurricane, and diminished again, after which occurred first rain and finally thunder.

---

[8] V. Bjerknes, Über einen hydrodynamischen Fundamentalsatz und seine Anwendung, besonders auf die Mechanik der Atmosphäre und des Weltmeers. Kongl. Sv. Vet. Akak. Handlingar. Bd. 31, No. 4. Stockholm, 1898. [See also the translations and remarks in Monthly Weather Review, June, 1900, p. 250; October, 1900, pp. 434–442; December, 1900, pp. 532–535. See also my "Preliminary Studies." Annual Report Chief Signal Officer U. S. Army, 1889, Appendix. See also Smithsonian meteorological tables, 1893, 1897, 1906.—*C. A.*]

The rapid covering of the sky with thick clouds, as also the subsequent rain and thunder, are evident signs that the air was forcibly driven upward. How this ascent originated and was maintained is seen from fig. 31, which presents a vertical section at right angles to the front of the thunderstorm. The cold specifically heavy lowest air presses under the lighter warmer air, whereby the latter is forcibly driven upward. An experiment that I have performed with two

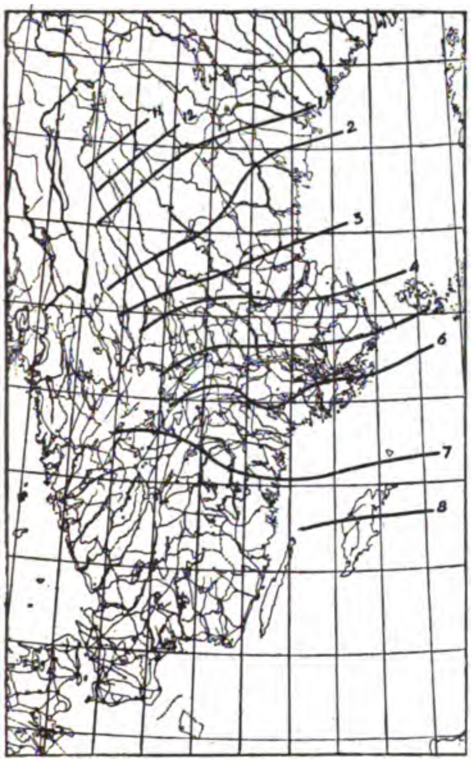


FIG. 29.—Isochrones of the thunderstorm gust of October 4, 1908.

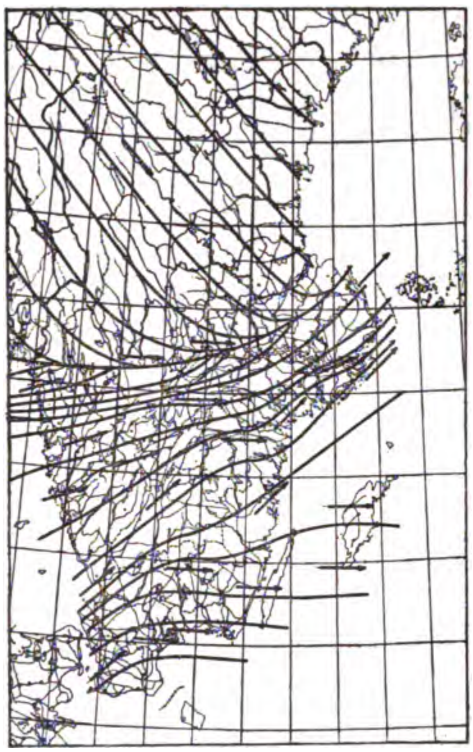


FIG. 30.—Wind paths for 2 p. m. October 4, 1908.

masses of water of different specific gravities shows the correctness of this interpretation; the form of the separating surface[9] between the warm and cold air, as shown in fig. 31, is copied from this experiment.

The intersection of this surface of separation and the surface of the earth is also the line of convergence of the winds. On the other

[9] Or discontinuous surface.—*C. A.*

hand, thunder can only occur when the warm air has attained considerable altitude and therefore occurs about as shown in fig. 31.

Now the Bjerknes solenoids are localized in the surface of separation between the warm and cold air. The steeper the slope of this surface by so much the more numerous are the solenoids. Therefore they are nearly all collected in the region close behind the line of convergence of the wind. Here, also, occur the tornado winds.

From the meteorological observation made at 2 p. m. on this date, October 4, 1908, it follows that the specific weight of the air south of the line of convergence of the winds was 0.001 190, but north of that line it was 0.001 215. When the front of the thunder gust passes over a locality, then in a few moments the warm, light air that lay above that place is replaced to a considerable height by cold, heavy air. The consequence is that the local barometer suddenly rises.

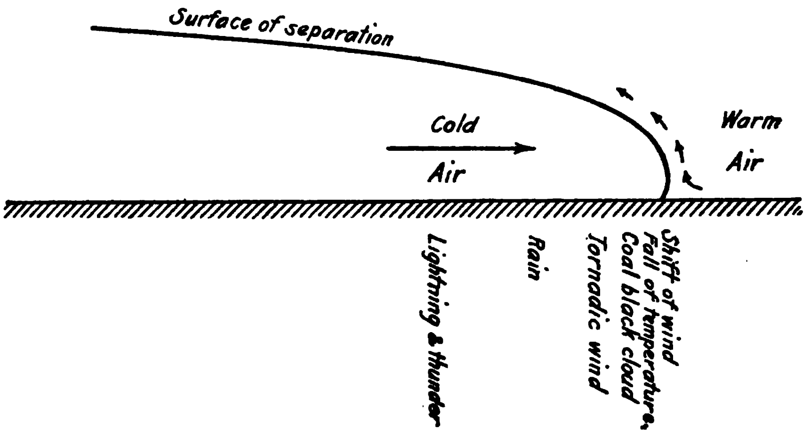


FIG. 31.—Vertical section through a thunder gust.

At Stockholm this rise amounted to 1.1 millimeters. From this rise and the above given specific weights, the depth of the cold stratum of air is computed to be 580 meters. This altitude, of course, holds good only for the front of the gust. At the back of the gust the cold stratum of air must be considerably thicker. But if we adopt this minimum altitude, 580 meters, and the above specific weights, 0.001 190 and 0.001 215, we compute that in this gust there has been active a number of solenoids amounting to at least

$$A = 1\ 180\ 000 \text{ solenoids.}$$

Now in order to answer the question how a hurricane wind could be formed, although the distribution of atmospheric pressure shown on the synoptic weather charts only corresponded to a moderately strong

wind, we have first to compute the quantity of energy E that in this gust was transformed from thermal into mechanical energy. According to the theory of heat, when a gas or a fluid passes through a reversible process

$$E = -m \int v dp \tag{9}$$

Where p is the pressure, v the specific volume, and m the mass of the gas or the fluid. But according to Bjerknes

$$A = -\int v dp \tag{10}$$

where A is the number of solenoids. Therefore

$$E = mA \tag{11}$$

Hence we deduce the following theorem:

The quantity of energy that passes from heat over into mechanical energy when a circulating quantity of gas or fluid completes one transformation is equal to its mass multiplied by the number of solenoids that exist within it.

In order to obtain the quantity of energy, e, per unit of time, we have to divide this quantity by the time, T, required for one transformation. Hence

$$e = \frac{mA}{T} \tag{12}$$

If the length of the front line of the gust be estimated at 200 kilometers, then from the above data for the thunder gust of October 4, 1908, and in accordance with formulæ (12) there easily results

$e = 232$ million horsepower.

Such a powerful development of mechanical energy as this must, of course, produce tornado winds, even if the distribution of atmospheric pressure does not allow us to expect winds of any considerable strength. (I must here express my warmest thanks to Dr. M. Jansson for his very complete collection of observations of this thunder gust, who placed them freely at my disposal for dynamic discussion and without which this computation of the energy would have been impossible.)

13.

Dr. N. Ekholm has called my attention to the fact that the strength of the wind depends not only on the gradient of pressure, but also on the rate of local change of pressure per unit of time. He has studied a large number of synoptic charts in the following manner: Under each station he inscribes the local change of pressure in the last 12 hours, and then with the aid of these numbers charts the lines of

equal change of pressure per unit of time, or the so-called *isallobars*.[10] Fig. 32 shows such a chart. The heavier lines on this chart are isobars, the finer lines are isallobars. During the preceding 12 hours the atmospheric pressure has remained stationary along the isallobar marked 0, or more correctly, it has risen as much as it has fallen during that interval; during that same interval of time the pressure has risen by 2 millimeters of mercury along the isallobar marked +2, and so on for the other lines. For the sake of simplicity we will

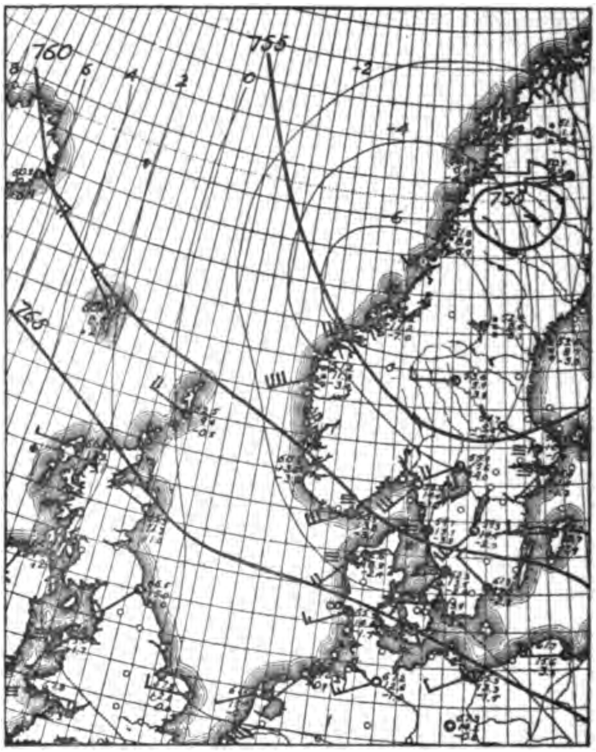


FIG. 32.—Synoptic weather chart for 8 a. m., October 4, 1908, with its isallobars.

imagine a gradient connecting successive isallobars, that is directed perpendicularly to them and toward the region of falling pressure.

[10] See Nils Ekholm, Wetterkarten der Luftdruckschwankungen. Met. Zeit., 1904, pp. 345–357. Die Luftdruckschwankungen und deren Beziehung zu der Temperatur der oberen Luftschichten. Met. Zeit., Hann-Band, 1906, pp. 228–242. Ueber die unperiodischen Luftdruckschwankungen und einige damit zusammenhängende Erscheinungen. Met. Zeit., 1907, pp. 1–11, 102–113, and 145–159. Om lufttryckets ändringar och därmed sammanhängande företeelser. Ymer, Tidskrift utgifven af Svenska Sällskapet för Antropologi och Geografi, Jahrg. 1908, pp. 345–406.

When this isallobaric gradient coincides approximately with the direction of the wind, then the strength of the wind is considerably greater than that which experience shows corresponds to the current local pressure gradient, as shown by the isobars. On fig. 32, at Christiansund and at Florö, on the west coast of Norway, are shown winds that have been increased by this coincidence.

I have not yet discovered the cause of this peculiar phenomenon; it can probably be deduced from the hydrodynamic equations of motion.

The chart, fig. 32, represents the weather of 8 a. m., October 4, and therefore immediately before the beginning of the above-mentioned thunder gust. This chart leads to the suspicion that in the production of the gust the isallobaric field has played an important part, possibly of an "auslösender," i. e., releasing or liberating nature.

Finally, I remark that in any statistical deduction of the relation between pressure and wind from a large mass of observational material it is necessary to exclude all those synoptic weather charts that contain curved isobars, periodical movements of the air, thunder gusts, and steep isallobaric gradients.

(XVII) FREE AIR DATA AT MOUNT WEATHER FOR OCTOBER, NOVEMBER, AND DECEMBER, 1910.

By the Aerial Section—WILLIAM R. BLAIR in charge.

In this period of 92 days, 92 ascensions were made at Mount Weather, 85 by means of kites and 7 by means of captive balloons. The highest altitudes reached in the kite flights average 3563 meters above sea level in October, 3030 in November, 2764 in December and 3115 in the period. The October mean is the station's highest average for any month so far. The average for the balloon ascensions is 1703 meters above sea level. The highest kite flight of the period, 6008 meters above sea level, was made on October 12, and the highest captive balloon ascension, 2455 meters above sea level, on November 20.

The prevailing wind for October was west; for November and December, northwest. The wind velocity was exceptionally high for the period, especially so in November. The mean wind velocities for the months are, October, 7.9 meters per second; November, 11.3: and December, 10.2. The barogram for the period showed a greater number of maxima and minima than that for the corresponding period of last year, but the extreme range of the barometer was not so great. This condition obtained more especially in October. The isothermals, on Charts XIX to XXIV, are characteristic of the surface pressure conditions. One or more inversions of temperature[1] were observed in 81 of the 92 ascensions made, whereas for this period last year inversions of temperature were observed in 70 of the 89 ascensions made. Inversions of temperature were observed in 26 of the 31 ascensions made in October this year and in 19 of the 31 made in the same month last year. The separate observations of the temperature gradient as well as the variation in altitude of a given isotherm further emphasize the relation between free air temperatures and surface pressure.

The record of cloudiness at Mount Weather for the period appears in the following table:

Month.	Number of days—			Mean Cloudiness.
	Clear.	Partly cloudy.	Cloudy.	
October	16	8	7	3.7
November	4	13	13	6.4
December	12	8	11	5.4

[[1] On Chart XXIV, opposite the "Inversion Layer" of December 16, 1910, the reader will please add, in red ink, "Max. −12.9°."—Editor.]

A peculiarity of the November observations is that at no hour was the mountain mean as high as either of the corresponding valley means. This has happened in four other months since the valley observations were begun, viz, March, June, and December, 1909, and June, 1910. In every case either the cloudiness or the wind velocity, or both, as in the present case, was exceptionally high for the month.

The observations of mountain and valley temperatures at the three stations for the three months are shown in figs. 11, 12, and 13.

It will be observed in all three that the Trapp mean temperatures are quite uniformly higher than those of the mountain station. The uniformity of this difference in temperature, together with the fact that it seldom exceeds the dry air adiabatic rate of cooling or heating with altitude, or is less than two-thirds of this rate, leads to the conclusion that the temperature of the lower station is chiefly controlled by the cooler air settling from the mountain top. The influence of the direct insolation and radiation at Trapp is of secondary importance. The Audley temperatures sustain no such relation as this to those at Mount Weather. The more important factor in the determination of the temperature at Audley seems to be the direct effect of insolation and radiation at that station under the quieter and probably clearer conditions than those that obtain on the mountain top. The settling of cooler air from higher altitudes is of course operative, but not to such an extent as to prevent inversions of temperature at night unless, as above stated, the weather be exceptionally cloudy, or the wind exceptionally high, or both. It should be kept in mind that Trapp is close to the foot of the mountain on its sheltered southeast side, while Audley is located in a wide valley well away from and to the northwest of the mountain range.

Figs. 14 and 15 are, respectively, the projections on an east-up plane and on an east-north plane of the wire in the kite flight of November 3, 1910. The dots or angles show where kites were attached to the wire. The head kite was flying in a south wind while the seventh was flying in a north wind of much higher velocity. The wind directions and temperatures at the different levels, also the surface pressure distribution (see tabular data following) are very interesting. The depth of the northerly wind increased 400 meters in four and one-half hours. The air pressure at the base station was falling more or less rapidly during the day. It should be noted that the computations for figs. 14 and 15 are approximations based on observations of azimuth and elevation of each kite, the length of wire between kites, and the altitude (computed barometrically) of the head kite.

Surface temperatures.

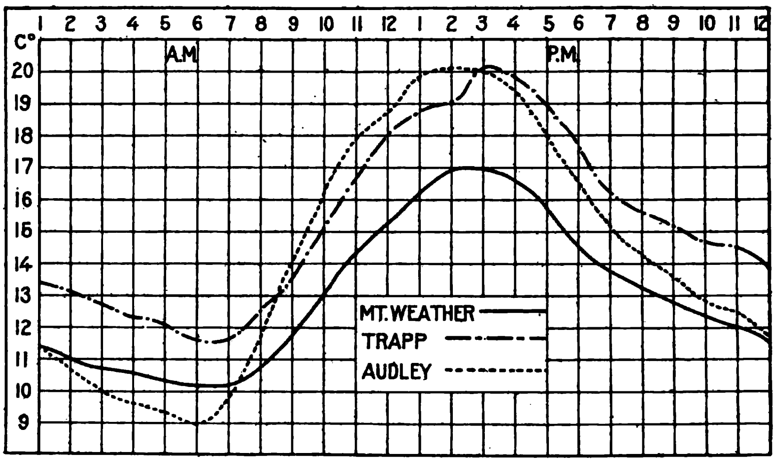


FIG. 11.—Mean hourly temperatures, October, 1910.

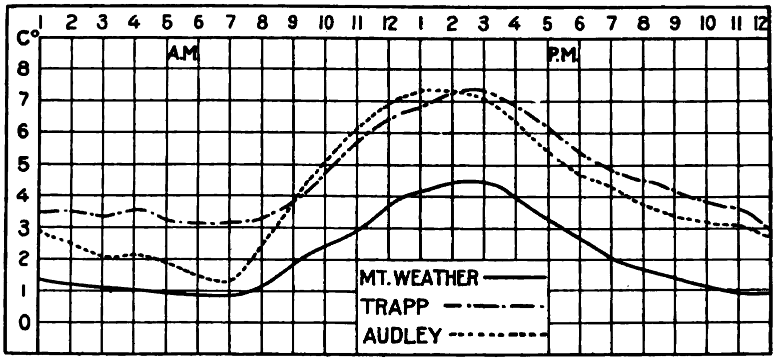


FIG. 12.—Mean hourly temperatures, November, 1910.

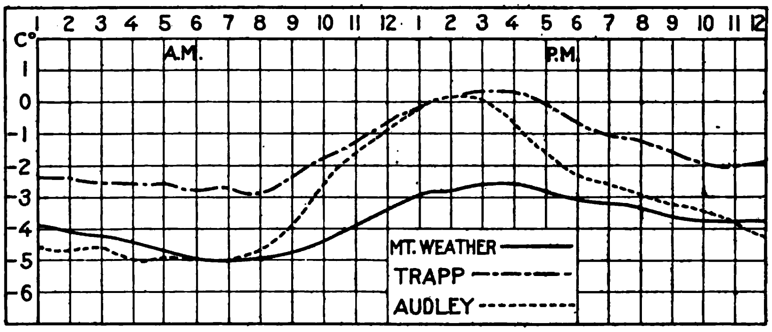


FIG. 13.—Mean hourly temperatures, December, 1910.

Kite flight of November 3, 1910.

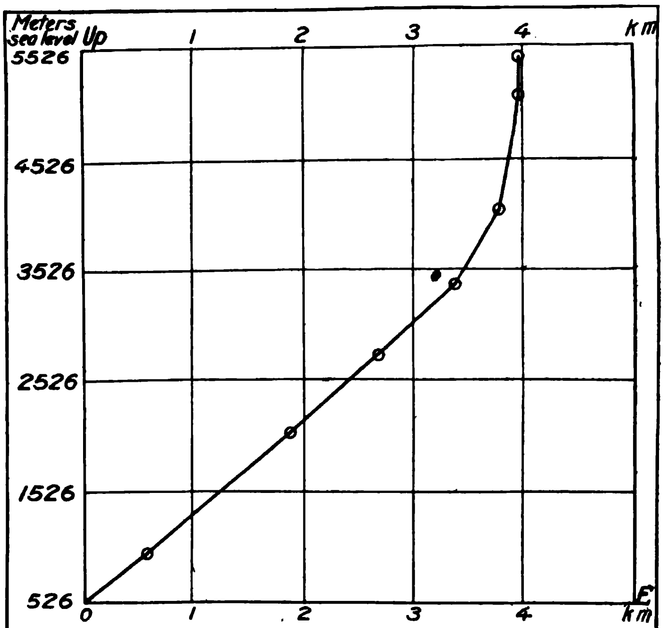


Fig. 14.

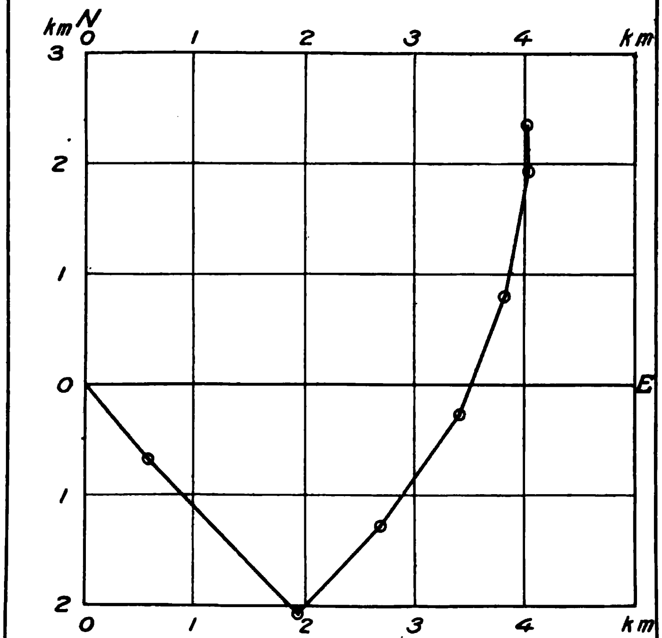


Fig. 15.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
October 1:	*mm.*	° *C.*	%		*m.p.s.*	*m.*	*mm.*	° *C.*	%		*m.p.s.*
9:00 a. m.	714.1	20.4	65	wsw.	8.0	526	714.1	20.4	65	wsw.	8.0
9:11 a. m.	714.0	20.8	64	wsw.	8.0	928	681.5	17.2	......	w.	13.4
9:23 a. m.	714.0	20.8	65	wsw.	8.0	1414	643.7	15.0	......	wnw.	22.4
9:29 a. m.	714.0	20.9	64	wsw.	8.0	1728	620.3	13.8	......	wnw.	20.1
9:37 a. m.	713.9	21.1	64	wsw.	8.0	1824	613.3	15.0	......	wnw.	15.0
9:50 a. m.	713.6	21.4	63	wsw.	8.0	2204	586.2	13.1	......	wnw.	11.6
10:03 a. m.	713.6	21.6	63	wsw.	8.0	2696	552.8	9.9	......	wnw.	15.0
10:16 a. m.	713.5	22.3	61	wsw.	8.0	3207	519.8	6.5	......	wnw.	20.1
10:50 a. m.	713.1	23.3	59	wsw.	8.5	3887	478.0	1.0	......	wnw.	21.4
11:37 a. m.	712.8	24.8	51	w.	10.7	4393	448.9	− 1.6	......	wnw.	....
12:06 p. m.	712.6	25.6	47	wsw.	12.1	5494	390.4	− 7.6	......	wnw.	....
12:33 p. m.	712.5	26.4	45	w.	12.1	5028	414.5	− 5.2	......	wnw.	....
12:33 p. m.	712.5	26.4	45	w.	12.1	4664	432.2	− 4.2	......	wnw.	....
1:20 p. m.	712.3	27.4	40	wsw.	10.7	3738	486.8	2.1	......	wnw.	....
2:10 p. m.	711.9	28.1	30	wsw.	8.9	2857	541.1	4.2	......	wnw.	....
3:00 p. m.	711.8	27.7	30	w.	12.5	2267	581.2	9.4	......	wnw.	....
3:30 p. m.	711.8	27.5	30	w.	16.5	1769	616.8	13.8	......	wnw.	....
3:42 p. m.	711.8	27.3	31	w.	16.1	1369	646.3	17.6	......	wnw.	....
4:00 p. m.	711.8	27.0	32	w.	15.2	988	675.4	21.5	......	wnw.	....
4:17 p. m.	711.8	26.7	33	w.	15.2	526	711.8	26.7	33	w.	15.2
October 2:											
8:35 a. m.	718.0	11.3	57	nw.	10.7	526	718.0	11.3	57	nw.	10.7
8:51 a. m.	718.1	11.9	55	nw.	10.7	974	680.3	7.6	......	nnw.	....
8:55 a. m.	718.1	11.8	54	nw.	10.7	1278	656.0	11.7	......	nnw.	....
9:07 a. m.	718.1	11.8	56	nw.	11.6	1716	622.7	12.8	......	nnw.	16.8
9:11 a. m.	718.2	12.0	55	nw.	11.6	1969	604.3	14.7	......	nnw.	18.3
9:26 a. m.	718.2	12.2	56	nw.	8.9	2459	570.4	12.1	......	nw.	....
9:40 a. m.	718.3	12.4	54	nw.	9.8	3051	531.4	8.6	......	nw.	....
10:33 a. m.	718.6	13.6	49	nw.	8.9	3800	484.6	3.4	......	nw.	16.2
11:03 a. m.	718.7	14.2	50	nw.	5.8	3151	524.7	7.2	......	nw.	18.0
11:30 a. m.	718.8	15.1	49	nw.	7.2	2221	586.8	12.2	......	nnw.	....
11:42 a. m.	718.9	15.3	49	nw.	6.3	1810	616.5	9.7	......	nnw.	....
11:53 a. m.	719.0	16.1	49	nw.	6.3	1502	639.8	10.7	......	nnw.	....
11:56 a. m.	719.0	16.5	49	nw.	6.3	1260	658.7	8.5	......	nnw.	....
12:03 p. m.	719.0	16.0	49	nw.	6.7	915	686.6	10.3	......	nw.	....
12:13 p. m.	719.1	16.4	45	nw.	8.0	526	719.1	16.4	45	nw.	8.0

October 1.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 10000 m.; at maximum altitude, 9400 m.

There were no clouds until 11 a. m.; thereafter there were few to 2/10 Cu. from the west-northwest at an altitude of 2000 m.

At 8. a. m. a well-developed low was central north of the lower Lakes; pressure was moderately high over the Mississippi Valley and the Gulf States.

October 2.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 6700 m.; at maximum altitude, 5750 m.

A few Ci. from the northwest increased to 2/10 by 10:31 a. m. and decreased to few by the end of the flight.

High pressure was central over Michigan and low pressure off the coast of New Brunswick.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
October 3:	*mm.*	° *C.*	%		*m.p.s.*	*m.*	*mm.*	° *C.*	%		*m.p.s.*
7:06 a. m.	723.8	11.8	70	se.	5.4	526	723.8	11.8	70	se.	5.4
7:15 a. m.	723.8	12.0	67	se.	6.7	842	697.0	11.0	......	s.	....
7:34 a. m.	723.9	12.6	65	s.	6.7	1404	652.0	12.5	......	sw.	....
7:39 a. m.	723.9	12.8	65	ese.	6.7	1580	638.5	12.7	......	w.	....
9:28 a. m.	724.1	14.0	60	se.	8.0	2329	584.3	10.4	......	w.	....
9:58 a. m.	724.1	15.0	64	se.	8.9	1771	624.4	11.3	......	sw.	....
10:05 a. m.	724.1	15.2	62	se.	8.9	1585	638.5	11.8	......	sw.	....
10:25 a. m.	723.9	15.8	65	se.	8.8	1395	652.9	13.2	......	sw.	....
10:34 a. m.	724.0	16.0	65	se.	8.8	1012	683.5	11.3	......	sw.	....
10:40 a. m.	723.9	16.0	64	se.	6.7	526	723.9	16.0	64	se.	6.7
October 4:											
6:39 a. m.	724.1	13.8	96	se.	5.8	526	724.1	13.8	96	se.	5.8
6:48 a. m.	724.1	13.6	98	se.	5.8	949	688.9	15.7	......	s.	....
6:57 a. m.	724.1	13.7	99	se.	6.3	1348	657.3	15.7	......	s.	....
7:08 a. m.	724.1	13.6	99	se.	6.3	1678	632.2	13.5	......	ssw.	11.6
7:22 a. m.	724.0	14.3	96	se.	6.7	2179	595.9	14.0	......	ssw.	15.0
7:39 a. m.	723.9	14.4	96	se.	8.9	3045	537.3	9.3	......	sw.	23.2
8:01 a. m.	723.8	14.7	95	se.	10.3	3524	507.0	4.7	......	sw.	21.7
8:25 a. m.	723.8	15.8	89	se.	9.8	3757	492.9	3.0	......	sw.	25.0
8:34 a. m.	723.9	16.4	86	se.	9.8	3523	507.0	5.0	......	sw.	21.7
8:58 a. m.	723.9	16.4	85	se.	10.7	3044	537.3	9.1	......	sw.	20.0
9:20 a. m.	723.8	16.3	86	se.	10.3	2165	596.8	13.1	......	ssw.	16.8
9:36 a. m.	723.7	17.2	83	se.	10.7	1780	624.7	14.5	......	ssw.	16.8
10:08 a. m.	723.5	18.8	76	se.	10.7	526	723.5	18.8	76	se.	10.7
October 5:											
7:15 a. m.	721.5	16.8	97	s.	6.7	526	721.5	16.8	97	s.	6.7
7:18 a. m.	721.5	16.8	98	s.	6.7	853	694.6	19.8	......	ssw.	....
7:39 a. m.	721.7	16.8	98	sse.	7.2	1518	643.3	16.3	......	sw.	....
9:48 a. m.	721.6	21.3	81	sse.	5.4	1929	612.7	14.9	......	sw.	4.6
10:04 a. m.	721.5	22.0	78	s.	5.4	1618	635.4	17.3	......	s.	8.0
10:35 a. m.	721.4	22.7	75	sse.	6.7	1311	658.6	17.8	......	ssw.	....
10:46 a. m.	721.3	23.8	74	sse.	8.9	876	692.8	18.8	......	s.	....
11:00 a. m.	721.2	23.5	71	s.	8.8	526	721.2	23.5	71	s.	8.8

October 3.—Six kites were used; lifting surface 38.8 sq. m. Wire out, 5700 m.; at maximum altitude, 5100 m.

There were no clouds.

High pressure was central over New England. Pressure was low over the Canadian Northwest and the Great Plains Region.

October 4.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 6100 m.; at maximum altitude, 5200 m.

There were clouds as follows: 6/10 to 8/10 Ci.-St. and A.-St. from the southwest; light fog until 7:30 a. m.; thereafter 2/10 Cu. from the south and 2/10 to 4/10 low St. from the southeast.

At 8 a. m. pressure was high off the middle Atlantic coast and low over Saskatchewan.

October 5.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 6500 m.; at maximum altitude, 4500 m.

There were 2/10 to 4/10 Ci and 2/10 to 1/10 A.-Cu from the southwest, 4/10 St. from the south, at an altitude of 850 meters, had disappeared by the end of the flight.

A high-pressure area was central off the Virginia Capes. Low-pressure areas were north of Lake Superior and over Oklahoma, respectively.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Pressure.	Temperature.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910.											
October 6:											
First flight—	*mm.*	*° C.*	*%*		*m. p. s.*	*m.*	*mm.*	*° C.*	*%*		*m. p. s.*
6:49 a. m....	717.8	17.6	90	s.	7.2	526	717.8	17.6	90	s.	7.2
6:51 a. m....	717.8	17.5	90	s.	7.2	867	689.9	19.4	......	ssw.	15.0
7:09 a. m....	717.8	17.6	94	s.	7.2	1350	652.1	16.4	......	ssw.	16.7
7:28 a. m....	717.8	17.2	98	s.	8.5	2013	603.0	13.4	......	sw.	....
7:40 a. m....	717.8	17.2	100	s.	8.5	2286	584.0	12.7	......	sw.	13.7
7:58 a. m....	717.8	17.3	100	s.	7.2	2878	544.2	10.4	......	sw.	14.2
8:07 a. m....	717.8	17.3	100	s.	6.7	3216	522.4	8.3	......	sw.	15.5
8:20 a. m....	717.7	17.4	100	s.	7.2	3907	480.2	4.5	......	sw.	18.5
8:35 a. m....	717.7	17.6	99	s.	7.2	4232	461.1	2.5	......	sw.	19.5
8:45 a. m....	717.6	17.8	98	s.	6.7	3996	474.4	3.5	......	sw.	19.5
9:05 a. m....	717.6	18.3	95	s.	5.8	3628	496.2	5.0	......	sw.	17.5
9:17 a. m....	717.5	18.6	93	s.	7.6	2673	556.8	11.3	......	sw.	12.4
9:30 a. m....	717.4	19.1	91	s.	7.6	1744	621.8	13.4	......	sw.	....
9:50 a. m....	717.3	20.4	84	s.	7.2	1273	657.6	16.7	......	ssw.	....
10:01 a. m....	717.2	21.6	77	s.	8.0	927	684.6	15.6	......	s.	....
10:06 a. m....	717.2	21.8	74	s.	8.5	526	717.2	21.8	74	s.	8.5
Second flight—											
10:17 a. m....	717.1	22.0	73	s.	8.5	526	717.1	22.0	73	s.	8.5
10:24 a. m....	717.1	22.6	72	s.	8.9	957	682.4	18.3	......	ssw.	....
10:28 a. m....	717.1	22.6	71	s.	8.0	1068	673.6	19.1	......	ssw.	....
10:40 a. m....	717.1	22.8	70	s.	9.4	1693	626.2	15.2	......	sw.	....
10:55 a. m....	717.0	23.4	65	s.	8.9	2378	577.6	13.4	......	sw.	....
11:02 a. m....	717.0	23.2	65	s.	10.3	2673	557.6	11.0	......	sw.	....
11:06 a. m....	716.9	23.5	66	s.	9.8	2784	550.3	11.5	......	sw.	....
11:27 a. m....	716.7	23.9	61	s.	10.3	3534	502.6	6.1	......	sw.	....
11:47 a. m....	716.5	24.0	60	s.	11.2	4200	463.1	1.6	......	sw.	....
12:20 p. m....	716.3	25.2	60	s.	8.9	4386	452.5	0.4	......	sw.	....
1:14 p. m....	715.9	25.6	54	s.	11.6	3889	480.6	2.1	......	sw.	....
3:09 p. m....	715.0	26.3	53	s.	12.5	3184	523.3	6.9	......	sw.	....
3:33 p. m....	715.0	26.0	53	s.	9.8	2690	555.3	11.5	......	sw.	....
3:42 p. m....	715.0	25.4	56	s.	9.8	2144	592.4	15.0	......	sw.	....
3:52 p. m....	715.0	25.4	57	s.	9.8	1915	608.6	13.5	......	sw.	....
4:05 p. m....	715.0	26.0	53	s.	9.4	1655	627.7	15.0	......	sw.	....
4:23 p. m....	715.0	26.0	56	s.	8.9	1055	673.0	20.5	......	ssw.	....
4:31 p. m....	715.0	25.6	56	s.	8.5	526	715.0	25.6	56	s.	8.5
October 7:											
1:06 p. m......	721.2	10.9	87	nw.	6.7	526	721.2	10.9	87	nw.	6.7
1:10 p. m......	721.2	10.7	88	nnw.	6.7	904	689.1	7.2	......	n.	12.1
1:20 p. m......	721.3	10.8	90	nnw.	6.3	1112	672.0	8.3	......	n.	11.4
1:23 p. m......	721.3	10.8	90	nnw.	6.7	1303	656.7	8.5	......	n.	9.6
1:36 p. m......	721.5	10.7	90	nnw.	8.9	1557	645.0	7.9	......	nne.	8.7
2:28 p. m......	721.8	10.6	88	nnw.	8.9	1606	633.5	7.1	......	nne.	6.9
4:14 p. m......	722.0	10.6	85	nw.	8.9	526	722.0	10.6	85	nw.	8.9

October 6.—First flight: Five kites were used; lifting surface, 32.0 sq. m. Wire out, 7500 m.; at maximum altitude, 7200 m.

There were a few to 10/10 St. from the south-southwest. Dense fog from 7:46 to 8:28 a. m. The head kite was in the clouds, except at short intervals, from 7:17 to 9:36 a. m.

Second flight: Six kites were used; lifting surface, 38.3 sq. m. Wire out, 10000 m., at maximum altitude.

There were a few to 3/10 St., changing gradually from south-southwest to southwest.

Pressure was high over the North Carolina coast and low over western New York.

October 7.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 5300 m.; at maximum altitude, 4400 m.

There were 6/10 to 7/10 A. St. from the southwest and 3/10 to 4/10 St. from the north. Light rain 2:50 to 3 p. m.

An area of high pressure was central over Lower Michigan. Pressure was low over the Gulf of Mexico and off the New England coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
October 8:	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
1:30 p. m.	721.3	7.4	100	n.	2.7	526	721.3	7.4	100	n.	2.7
1:43 p. m.	721.3	7.8	100	n.	2.2	1530	639.0	8.9	......	se.	....
1:48 p. m.	721.2	7.8	100	n.	2.2	1157	668.2	9.6	......	se.	....
2:03 p. m.	721.2	7.8	100	n.	2.7	852	693.3	7.7	......	se.	....
3:07 p. m.	720.2	7.8	100	n.	1.8	526	720.2	7.8	100	n.	1.8
October 9:											
9:10 a. m.	715.6	9.3	100	w.	10.7	526	715.6	9.3	100	w.	10.7
9:12 a. m.	715.5	9.3	100	w.	10.7	626	707.0	8.4	......	wnw.	13.3
9:37 a. m.	715.3	9.7	100	wnw.	10.3	1182	661.1	11.1	......	nw.	16.7
9:54 a. m.	715.1	10.4	100	wnw.	10.7	1753	617.4	9.9	......	nw.	21.9
10:08 a. m.	715.1	11.3	96	wnw.	9.8	2269	580.9	6.8	......	nw.	22.2
10:19 a. m.	715.1	11.8	91	wnw.	11.2	2818	542.6	4.4	......	nw.	19.0
10:32 a. m.	715.0	13.2	85	wnw.	9.8	3206	517.5	5.4	......	nw.	22.0
10:52 a. m.	715.0	14.0	81	wnw.	6.3	3434	503.4	3.4	......	nw.	....
1:01 p. m.	712.9	18.4	51	nw.	10.7	526	712.9	18.4	51	nw.	10.7
October 10:											
8:26 a. m.	718.3	7.8	78	nw.	8.5	526	718.3	7.8	78	nw.	8.5
8:31 a. m.	718.3	7.9	78	nw.	8.5	881	688.0	4.1	91	nnw.	....
8:40 a. m.	718.3	7.9	78	nw.	8.9	1226	659.2	1.7	100	nnw.	....
8:46 a. m.	718.3	8.0	78	nw.	8.9	1385	646.6	10.0	......	nnw.	....
9:01 a. m.	718.3	8.2	77	nw.	8.0	1788	616.2	11.0	......	n.	....
9:15 a. m.	718.3	8.2	75	nw.	7.6	2362	575.2	9.7	......	n.	....
9:45 a. m.	718.3	9.3	71	nw.	8.9	2744	549.5	8.9	......	n.	....
10:07 a. m.	718.3	9.8	68	nw.	9.8	3372	509.2	5.1	......	n.	....
10:20 a. m.	718.4	10.2	68	nw.	7.6	3910	476.7	2.0	......	n.	....
11:05 a. m.	718.6	10.6	66	nw.	8.9	4844	424.5	−1.8	......	n.	18.3
11:30 a. m.	718.5	11.5	63	nw.	8.0	5448	393.5	−5.9	......	n.	....
11:52 a. m.	718.4	11.7	61	nw.	8.5	4897	421.9	−3.1	......	n.	....
12:19 p. m.	718.3	12.4	57	nw.	8.9	4173	462.0	1.1	......	n.	....
12:45 p. m.	718.2	12.9	55	nw.	7.6	3229	518.8	6.4	......	n.	....
1:09 p. m.	718.2	12.9	55	nw.	7.6	2517	565.5	8.8	......	n.	....
1:22 p. m.	718.2	13.0	53	nw.	7.2	1874	610.9	10.3	......	nne.	....
1:30 p. m.	718.2	13.0	55	nw.	5.8	1422	644.8	11.0	......	nne.	....
1:38 p. m.	718.2	13.2	54	nw.	6.3	1027	676.3	7.4	......	nnw.	....
1:43 p. m.	718.2	13.2	53	nw.	5.8	745	699.7	10.3	......	nw.	....
1:45 p. m.	718.2	13.2	53	nw.	5.8	526	718.2	13.2	53	nw.	5.8

October 8.—One captive balloon was used; capacity, 22.4 cu. m. Wire out, 2450 m. There was dense fog.

Pressure was high over Vermont and low over the Gulf of Mexico.

October 9.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 9000 m.; at maximum altitude, 8000 m.

Dense fog was followed at 9:39 a. m. by light fog which rose at 9:48 a. m. There were a few Ci.-Cu., also a few Cu., from the northwest.

At 8 a. m. of this date the pressure was low over the St. Lawrence and the Gulf of Mexico and high over the Middle West.

October 10.—Eight kites were used; lifting surface, 50.4 sq. m. Wire out, 10000 m.; at maximum altitude, 9200 m.

St.-Cu. from the north-northwest, at an altitude of 1300 m., diminished from 10/10 at the beginning of the flight to few by noon.

At 8 a. m. an extensive high was central over northern Indiana and Ohio; pressure was low over the Gulf of Mexico and over the lower St. Lawrence Valley.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
October 11:	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
2:59 p. m.	716.0	22.8	34	w.	4.5	526	716.0	22.8	34	w.	4.5
3:18 p. m.	715.9	22.9	33	w.	4.0	1390	647.6	16.2	......	wnw.	....
3:37 p. m.	715.9	23.3	36	wsw.	4.0	1081	671.5	18.2	......	w.	....
3:50 p. m.	715.8	23.5	38	wsw.	2.7	920	684.1	19.3	......	wsw.	....
3:58 p. m.	715.8	23.3	40	wsw.	2.7	526	715.8	23.3	40	wsw.	2.7
October 12:											
6:46 a. m.	715.3	14.0	53	wnw.	13.4	526	715.3	14.0	53	wnw.	13.4
6:53 a. m.	715.3	14.2	50	wnw.	13.4	881	686.1	16.2	......	wnw.	....
7:05 a. m.	715.3	14.2	49	wnw.	11.6	1153	664.5	18.3	......	nw.	....
7:15 a. m.	715.3	14.3	49	wnw.	11.6	1428	643.8	20.1	......	wnw.	....
7:40 a. m.	715.4	14.4	50	wnw.	12.5	2240	585.6	13.5	......	wnw.	....
7:49 a. m.	715.5	14.6	51	wnw.	12.1	2803	547.6	9.6	......	wnw.	....
8:07 a. m.	715.5	15.1	47	wnw.	11.2	3308	515.2	4.8	......	nw.	....
8:31 a. m.	715.5	15.4	46	wnw.	12.1	3780	486.2	− 0.4	......	nw.	....
8:46 a. m.	715.5	15.9	47	wnw.	14.3	4320	454.4	0.2	......	nw.	....
9:34 a. m.	715.3	16.8	50	wnw.	11.2	5283	402.8	− 4.3	......	nw.	....
10:07 a. m.	715.2	18.1	47	wnw.	12.1	6008	366.6	− 9.8	......	wnw.	....
11:07 a. m.	715.2	20.4	42	wnw.	13.4	5306	401.1	− 4.8	......	nw.	....
11:27 a. m.	715.2	21.1	40	wnw.	11.2	4556	440.7	− 0.4	......	nw.	....
11:41 a. m.	715.2	21.5	38	wnw.	10.7	4306	454.4	0.2	......	nw.	....
1:20 p. m.	715.2	23.1	28	wnw.	10.3	3797	484.4	2.2	......	nw.	....
1:29 p. m.	715.2	23.3	28	wnw.	10.3	3296	515.2	5.4	......	nw.	....
1:42 p. m.	715.2	23.6	29	wnw.	9.4	2791	547.6	9.6	......	nw.	....
1:53 p. m.	715.2	23.6	30	wnw.	9.8	2231	585.6	11.6	......	nw.	....
2:04 p. m.	715.2	23.9	30	wnw.	9.4	1914	608.1	12.2	......	nw.	....
2:13 p. m.	715.2	24.0	30	wnw.	8.5	1360	649.2	15.3	......	nw.	....
2:19 p. m.	715.2	23.8	29	wnw.	9.4	921	683.4	18.3	......	wnw.	....
2:28 p. m.	715.2	24.0	29	wnw.	9.4	526	715.2	24.0	29	wnw.	9.4
October 13:											
1:28 p. m.	722.1	11.4	47	se.	6.7	526	722.1	11.4	47	se.	6.7
1:37 p. m.	722.0	12.2	36	se.	8.0	867	693.0	7.1	......	se.	....
1:50 p. m.	721.8	12.0	41	se.	8.9	1444	646.2	11.1	......	sw.	....
2:12 p. m.	721.8	13.2	36	se.	6.7	2008	604.2	11.1	......	wsw.	....
3:40 p. m.	721.4	13.8	44	se.	9.4	3321	515.3	4.2	......	wsw.	12.0
4:00 p. m.	721.4	13.4	45	se.	10.7	4382	451.5	− 3.8	......	sw.	15.3
4:09 p. m.	721.4	13.6	49	se.	8.9	4322	455.0	− 4.1	......	sw.	16.9
4:35 p. m.	721.4	12.8	57	se.	8.0	3255	519.7	4.4	......	wsw.	....
4:47 p. m.	721.4	12.6	58	se.	9.4	2563	565.3	8.1	......	wsw.	....
5:07 p. m.	721.4	12.0	59	se.	9.8	1631	632.1	12.2	......	sw.	....
5:15 p. m.	721.4	11.8	64	sse.	9.4	1386	650.7	11.2	......	s.	....
5:17 p. m.	721.4	11.7	64	sse.	9.4	1158	668.7	11.7	......	s.	....
5:22 p. m.	721.4	11.6	70	se.	9.8	981	683.1	8.7	......	s.	....
5:28 p. m.	721.4	11.3	60	se.	9.8	526	721.4	11.3	60	se.	9.8

October 11.—One captive balloon was used; capacity, 22.4 cu. m. Wire out, 2150 m. There were no clouds.

Pressure was high over West Virginia and low over the Gulf of St. Lawrence.

October 12.—Nine kites were used; lifting surface, 56.7 sq. m. Wire out, 12000 m.; at maximum altitude, 11500 m.

The sky was cloudless, but there was light haze.

At 8 a. m. pressure was high north of the upper Lakes, low over the lower St. Lawrence Valley, and comparatively flat from the lower Lakes southward to the Gulf of Mexico.

October 13.—Six kites were used; lifting surface, 42.7 sq. m. Wire out, 7500 m.; at maximum altitude, 6700 m.

The sky was cloudless.

An area of high pressure was central over New York. Pressure was low west of the Mississippi and over the Gulf of Mexico.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
October 14:	*mm.*	° *C.*	%		*m.p.s.*	*m.*	*mm.*	° *C.*	%		*m.p.s.*
6:49 a. m.	720.5	14.8	74	sw.	6.3	526	720.5	14.8	74	sw.	6.3
6:55 a. m.	720.5	14.8	74	sw.	4.9	899	689.6	16.3	......	sw.	....
7:06 a. m.	720.5	14.2	76	sw.	4.5	1158	668.9	16.2	......	w.	....
7:30 a. m.	720.6	15.0	73	sw.	6.3	1404	650.0	14.4	......	w.	6.7
7:55 a. m.	720.6	15.0	73	wsw.	5.8	1904	612.5	10.4	......	wnw.	6.7
9:30 a. m.	720.2	17.1	66	wsw.	5.4	2426	575.0	6.7	......	wnw.	....
9:34 a. m.	720.2	17.5	65	wsw.	5.8	2684	557.4	7.8	......	wnw.	....
9:36 a. m.	720.2	17.7	64	wsw.	5.8	2710	555.6	7.2	......	wnw.	13.6
9:40 a. m.	720.2	18.0	65	wsw.	6.3	2524	568.0	7.2	......	wnw.	....
9:42 a. m.	720.2	18.0	65	wsw.	6.3	2211	590.0	7.0	......	wnw.	....
9:54 a. m.	720.1	18.4	62	wsw.	5.4	1936	609.9	10.0	......	wnw.	....
10:02 a. m.	720.1	18.1	65	wsw.	5.8	1578	636.5	12.9	......	wnw.	....
10:20 a. m.	720.0	18.2	62	w.	5.4	1078	675.2	16.9	......	w.	....
10:32 a. m.	720.0	18.4	60	wsw.	4.5	526	720.0	18.4	60	wsw.	4.5
October 15:											
6:45 a. m.	718.7	16.4	82	w.	6.3	526	718.7	16.4	82	w.	6.3
6:49 a. m.	718.7	16.5	82	w.	6.3	692	704.9	16.8	......	wnw.	6.7
7:03 a. m.	718.7	16.9	80	w.	6.7	970	682.4	16.2	......	nw.	....
9:38 a. m.	718.7	20.0	68	wnw.	8.0	1306	656.3	14.6	......	nw.	6.7
9:43 a. m.	718.7	20.0	69	wnw.	8.0	1721	624.8	11.8	......	nw.	6.7
9:53 a. m.	718.6	20.0	69	wnw.	8.5	1304	656.3	14.5	......	nw.	....
9:56 a. m.	718.6	20.1	69	wnw.	8.5	973	682.4	17.6	......	nw.	....
10:05 a. m.	718.6	20.0	69	wnw.	8.9	805	695.9	20.4	......	nw.	....
10:19 a. m.	718.5	20.2	69	wnw.	8.9	846	692.3	16.8	......	nw.	....
10:28 a. m.	718.4	20.5	67	wnw.	8.5	526	718.4	20.5	67	wnw.	8.5
October 16:											
6:46 a. m.	715.4	18.4	73	w.	11.2	526	715.4	18.4	73	w.	11.2
6:51 a. m.	715.4	18.5	72	w.	11.2	901	693.8	16.8	......	wnw.	....
7:00 a. m.	715.4	18.3	74	w.	11.2	1290	654.2	14.7	......	nw.	....
7:06 a. m.	715.4	18.4	73	w.	11.6	1491	638.9	16.6	......	nw.	....
7:22 a. m.	715.4	18.6	74	w.	10.7	2149	591.3	11.6	......	nw.	....
7:42 a. m.	715.3	19.3	71	w.	12.1	3067	529.4	6.3	......	nw.	....
7:58 a. m.	715.3	19.8	70	w.	10.7	3554	498.9	3.5	......	nw.	....
8:17 a. m.	715.2	19.9	72	w.	11.2	3958	474.4	0.4	......	nw.	....
9:13 a. m.	714.9	19.8	69	w.	10.7	4600	437.6	− 2.1	......	nw.	14.0
9:40 a. m.	714.8	20.4	68	w.	11.6	3818	482.4	1.5	......	nw.	....
10:40 a. m.	714.4	22.2	61	w.	11.2	2639	556.9	9.6	......	nw.	....
10:55 a. m.	714.2	22.7	59	w.	11.2	1986	601.9	13.1	......	nw.	....
11:12 a. m.	714.1	23.8	48	w.	8.9	1424	643.2	13.9	......	nw.	....
11:22 a. m.	714.0	23.6	45	w.	9.8	900	681.9	18.5	......	wnw.	....
11:32 a. m.	713.9	24.0	43	w.	10.7	526	713.9	24.0	43	w.	10.7

October 14.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 5400 m.; at maximum altitude, 3700 m.

There were 6/10 to 7/10 A.-Cu. and A.-St. from the west.

Pressure was high over Virginia and comparatively low over Oklahoma.

October 15.—Eight kites were used; lifting surface, 50.9 sq. m. Wire out, 6400 m.; at maximum altitude, 5650 m.

Ci.-St. from the northwest increased from few at 6:30 a. m. to 4/10 by 9 a. m. After 9:30 a. m. there were a few Cu. from the northwest.

At 8 a. m. an extensive high, central over Kansas, covered most of the country. A tropical hurricane was central over Cuba.

October 16.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 10000 m.; at maximum altitude, 9000 m.

There were 2/10 to 8/10 A.-Cu. from the northwest before 9 a. m. and 1/10 Ci.-St. from the northwest thereafter.

Pressure was low over the Gulf of St. Lawrence and high over Kansas.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
October 17:	*mm.*	° *C.*	%		*m.p.s.*	*m.*	*mm.*	° *C.*	%		*m.p.s.*
1:21 p. m.	716.7	21.1	46	se.	2.2	526	716.7	21.1	46	se.	2.2
1:55 p. m.	716.4	20.6	49	se.	2.2	2355	577.0	8.8	......	nnw.	....
2:16 p. m.	716.4	20.8	44	e.	2.2	1995	602.5	10.7	......	nnw.	....
2:32 p. m.	716.3	21.0	46	se.	1.8	1484	640.3	11.8	......	nnw.	....
2:45 p. m.	716.3	20.9	41	se.	1.8	1129	667.8	15.3	......	n.	....
2:50 p. m.	716.3	20.7	42	se.	1.8	526	716.3	20.7	42	se.	1.8
October 18:											
1:15 p. m.	718.5	18.8	44	se.	6.3	526	718.5	18.8	44	se.	6.3
1:26 p. m.	718.4	19.2	47	ese.	5.8	730	701.5	15.3	......	se.	....
3:52 p. m.	717.9	18.1	67	se.	8.5	1065	673.6	11.6	......	sse.	6.2
4:09 p. m.	717.9	17.5	70	se.	8.9	1235	660.1	12.7	......	sse.	....
4:20 p. m.	717.9	17.3	71	se.	8.9	1729	622.5	12.6	......	sse.	....
4:27 p. m.	717.9	17.1	72	se.	9.4	1329	652.9	13.9	......	se.	....
4:32 p. m.	717.8	17.0	73	se.	8.9	1110	670.0	11.8	......	se.	....
4:46 p. m.	717.8	16.6	75	se.	7.6	526	717.8	16.6	75	se.	7.6
October 19:											
3.24 p. m.	714.7	17.4	96	e.	4.9	526	714.7	17.4	96	e.	4.9
3:30 p. m.	714.7	17.4	96	e.	4.9	910	683.3	14.9	......	se.	13.3
3:52 p. m.	714.6	17.8	94	e.	4.9	1343	649.1	11.9	......	se.	14.5
4:00 p. m.	714.6	17.6	94	e.	5.4	1413	643.7	12.5	......	se.	10.7
4:02 p. m.	714.6	17.8	94	e.	5.4	1308	651.8	12.6	......	se.	19.3
4:06 p. m.	714.6	17.6	96	e.	5.4	988	677.0	15.0	......	se.	20.0
4:11 p. m.	714.6	17.6	96	e.	5.4	743	696.8	16.6	......	ese.	20.0
4:30 p. m.	714.5	17.6	100	e.	7.6	526	714.5	17.6	100	e.	7.6

October 17.—Two captive balloons were used; capacity, 36.5 cu. m. Wire out, 3200 m.

There were a few A.-St., direction doubtful, at the end of the ascension.

High pressure was central over Pennsylvania and covered the lower Lakes and the Ohio Valley. A severe tropical hurricane was central over western Cuba, and the pressure was low off the coast of New Brunswick.

October 18.—Five kites were used; lifting surface, 37.4 sq. m. Wire out, 3970 m.; at maximum altitude, 2000 m.

There were few to 2/10 St.-Cu. from the south.

At 8 a. m. pressure was high over New England and low over Florida and South Dakota.

October 19.—Two kites were used; lifting surface, 13.1 sq. m. Wire out, 2200 m.; at maximum altitude, 2000 m.

There were 10/10 St. from the southeast before 4 p. m., from the south-southeast thereafter.

Pressure was high over New Jersey and low over Wisconsin.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
October 20:	*mm.*	° *C.*	%		*m.p.s.*	*m.*	*mm.*	° *C.*	%		*m.p.s.*
11:29 a. m......	710.2	17.9	99	nw.	10.7	526	710.2	17.9	99	nw.	....
11:33 a. m......	710.3	18.2	100	nw.	8.9	859	683.2	16.1	......	nnw.	....
11:48 a. m......	710.3	18.3	98	nw.	8.0	1330	646.3	13.9	......	nnw.	....
11:55 a. m......	710.3	18.2	97	nw.	8.9	1568	628.3	13.0	......	n.	....
12:06 p. m......	710.3	18.3	99	nw.	6.7	2063	592.5	12.3	......	n.	....
12:51 p. m......	710.4	19.8	86	nnw.	8.9	2879	537.6	9.4	......	n.	....
1:57 p. m......	710.5	20.0	85	nnw.	8.0	3892	475.6	5.7	......	n.	....
2:19 p. m......	710.5	20.2	82	nnw.	9.8	4359	449.1	4.4	......	nnw.	15.4
2:25 p. m......	710.5	20.4	80	nnw.	8.0	3972	470.9	4.2	......	nnw.	....
2:38 p. m......	710.6	20.6	78	nnw.	6.7	3343	508.5	6.4	......	nnw.	....
3:14 p. m......	710.6	21.2	75	nnw.	9.4	2116	589.5	11.8	......	nnw.	....
3:38 p. m......	710.7	21.0	73	nnw.	8.9	1285	650.4	15.7	......	n.	....
3:39 p. m......	710.7	21.0	73	nnw.	8.9	1202	656.7	14.7	......	n.	....
3:47 p. m......	710.7	20.6	72	nnw.	9.8	827	686.4	17.6	......	n.	....
3:54 p. m ...	710.7	20.6	73	nnw.	10.3	526	710.7	20.6	73	nnw.	....
October 21:											
1:18 p. m......	715.1	17.8	79	se.	7.6	526	715.1	17.8	79	se.	7.6
1:25 p. m......	715.0	18.3	79	se.	7.2	738	697.5	15.1	......	se.	....
1:57 p. m......	714.8	17.9	80	se.	8.0	881	685.8	16.8	......	sse.	....
2:32 p. m......	714.8	17.6	82	se.	9.8	1315	651.6	15.2	......	s.	7.6
2:42 p. m......	714.8	17.5	83	se.	11.2	1505	637.2	12.9	......	ssw.	6.7
3:31 p. m......	714.6	16.0	91	se.	11.6	1946	604.2	10.8	......	sw.	8.3
3:36 p. m......	714.6	15.9	91	se.	11.6	2187	587.0	9.5	......	sw.	8.3
3:40 p. m......	714.6	15.9	91	se.	11.6	2622	557.0	8.0	......	sw.	15.1
3:48 p. m......	714.5	15.8	92	se.	11.2	2953	534.8	7.0	......	sw.	15.1
4:02 p. m......	714.5	15.4	93	se.	10.7	2639	555.3	7.9	......	sw.	15.1
4:07 p. m......	714.5	15.4	93	se.	12.1	2096	593.1	7.3	......	sw.	8.4
4:12 p. m......	714.5	15.3	94	se.	11.2	2040	597.1	9.8	......	sw.	8.4
4:22 p. m......	714.6	15.1	94	se.	9.8	1532	634.5	13.9	......	sw.	....
4:42 p. m......	714.6	14.6	98	se.	9.8	1282	653.4	14.3	......	s.	....
4:53 p. m......	714.7	14.4	98	se.	10.3	875	685.8	12.1	......	se.	....
4:58 p. m......	714.7	14.3	98	se.	10.3	526	714.7	14.3	98	se.	10.3

October 20.—Seven kites were used; lifting surface, 44.1 sq. m. Wire out, 9000 m.; at maximum altitude, 7000 m.

There were 9/10 St.-Cu. from the north-northwest. These had decreased to 7/10 by 1:57 p. m. and to 1/10 by the end of the flight.

At 8 a. m., a tropical hurricane was central over the North Carolina coast. Low pressure was central over the lower St. Lawrence Valley and high over Nebraska.

October 21.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 6000 m.; at maximum altitude, 4800 m.

The sky was covered with St. from the south until about 3:30 p. m. and from the southeast thereafter, the change in direction occurring with change in altitude, which diminished from 1700 m. to 600 m.

At 8 a. m. low pressure was central over Wisconsin and high pressure over the St. Lawrence Valley.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m. Pressure.	Temperature.	Rel. hum.	Wind. Dir.	Wind. Velocity.	At different heights above sea. Height.	Pressure.	Temperature.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910.											
October 22:	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
8:45 a. m.	711.9	9.2	92	nw.	12.1	526	711.9	9.2	92	nw.	12.1
8:53 a. m.	711.9	9.8	86	nw.	11.2	810	687.9	6.8	......	nw.	16.3
9:09 a. m.	711.9	9.8	77	nw.	18.8	1075	666.3	11.6	......	wsw.	10.0
9:21 a. m.	711.9	10.0	77	nw.	15.2	1466	635.7	7.3	......	wsw.	12.0
10:05 a. m.	711.9	10.4	69	nw.	12.5	1888	603.6	3.5	......	wsw.	12.3
10:10 a. m.	711.9	10.4	68	nw.	11.6	2313	573.1	5.1	......	wsw.	22.7
10:17 a. m.	711.8	10.3	67	nw.	10.7	3018	525.3	2.2	......	wsw.	26.0
10:48 a. m.	711.7	10.6	68	nw.	10.7	3796	476.4	−2.5	......	sw.	21.0
11:15 a. m.	711.6	10.8	65	nw.	10.7	3208	512.4	1.5	......	sw.	22.3
11:42 a. m.	711.3	11.0	65	nw.	11.6	2736	542.2	4.0	......	sw.	23.3
12:01 p. m.	711.1	10.6	68	nw.	10.7	1890	601.8	7.1	......	w.	....
12:06 p. m.	711.0	10.9	66	nw.	10.7	1593	624.0	2.0	......	wnw.	....
12:12 p. m.	711.0	11.2	65	nw.	10.7	1353	642.9	2.6	......	wnw.	....
12:22 p. m.	710.9	11.2	65	nw.	10.7	832	685.2	7.1	......	wnw.	....
12:28 p. m.	710.8	11.6	62	nw.	10.7	526	710.8	11.6	62	nw.	10.7
October 23:											
8:22 a. m.	712.9	7.0	78	wnw.	11.6	526	712.9	7.0	78	wnw.	11.6
8:25 a. m.	712.9	7.2	63	wnw.	11.6	867	683.9	4.8	......	wnw.	17.0
8:33 a. m.	713.0	7.3	62	wnw.	10.7	1250	652.4	2.3	......	wnw.	23.2
8:47 a. m.	713.2	7.3	61	wnw.	15.2	1662	620.0	−0.3	......	wnw.	19.0
9:08 a. m.	713.3	7.8	55	wnw.	10.7	2354	568.4	−5.4	......	nw.	17.0
9:14 a. m.	713.3	8.0	51	nw.	10.7	2592	551.6	0.8	......	nw.	22.0
9:16 a. m.	713.3	8.0	51	nw.	10.7	2592	551.6	−0.4	......	nw.	23.4
9:32 a. m.	713.5	8.6	59	wnw.	10.3	2855	534.7	1.0	......	nnw.	....
10:12 a. m.	713.6	8.8	57	nw.	13.4	2604	552.5	2.5	......	nnw.	....
10:17 a. m.	713.6	9.0	58	wnw.	13.4	2286	574.6	3.8	......	......	....
10:32 a. m.	713.6	9.0	59	wnw.	13.4	1704	617.5	0.2	......	nw.	....
10:47 a. m.	713.6	9.0	59	wnw.	16.1	1094	665.9	3.8	......	nw.	....
11:26 a. m.	713.6	10.0	51	nw.	12.5	526	713.6	10.0	51	nw.	12.5
October 24:											
3:03 p. m.	713.8	13.4	49	sse.	4.5	526	713.8	13.4	49	sse.	4.5
3:12 p. m.	713.8	13.6	50	s.	4.5	786	691.9	8.6	......	s.	7.7
3:27 p. m.	713.7	13.3	55	s.	4.0	1374	644.2	6.4	......	ssw.	8.8
3:51 p. m.	713.6	13.1	54	s.	3.6	1662	621.9	4.8	......	wsw.	11.1
3:55 p. m.	713.6	12.9	54	s.	3.6	1953	600.1	5.5	......	wsw.	14.5
4:52 p. m.	713.5	12.2	59	s.	4.5	2533	558.7	2.9	......	wsw.	9.3
4:57 p. m.	713.5	11.9	59	sse.	5.4	3205	513.9	−1.9	......	wsw.	13.4
5:12 p. m.	713.5	11.9	48	se.	4.5	2685	548.9	0.7	......	w.	10.0
5:24 p. m.	713.4	11.6	64	sse.	5.4	1958	600.1	6.6	......	w.	13.0
5:27 p. m.	713.4	11.6	64	sse.	4.5	1725	617.4	5.9	......	w.	11.4
5:41 p. m.	713.3	11.4	64	s.	4.5	956	677.5	9.7	......	s.	7.7
5:46 p. m.	713.3	11.3	58	sse.	4.5	526	713.3	11.3	58	sse.	4.5

October 22.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 6500 m., at maximum altitude.

There were 2/10 to 5/10 St.-Cu. from the west-southwest until 10:45 a. m., from the west-northwest thereafter. There was 1/10 St. from the west-northwest until 9:03 a. m. The head kite was in the clouds at 10:15 a. m. and at intervals from 11:48 a. m. to 12:09 p. m.

Pressure was low over Maryland and north of Lake Huron and high over New Mexico.

October 23.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 7500 m.; at maximum altitude, 5600 m.

There were few to 3/10 A.-St. and Cu. from the northwest.

Pressure was low off the Maine coast, also over Manitoba, and high over the lower Mississippi Valley.

October 24.—Six kites were used; lifting surface, 43.2 sq. m. Wire out, 4700 m.; at maximum altitude, 4500 m.

There were 1/10 to 4/10 A.-Cu. from the southwest; after 3:50, 3/10 St.-Cu. and a few A.-St. from southwest.

The pressure was moderately high over the southeastern States. Pressure was low over the Gulf of St. Lawrence and north of Lake Superior.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910. October 25:	*mm.*	*° C.*	*%*		*m. p. s.*	*m.*	*mm.*	*° C.*	*%*		*m. p. s.*
8:19 a. m......	707.2	12.4	46	ssw.	7.6	526	707.2	12.4	46	ssw.	7.6
8:26 a. m......	707.1	12.6	45	ssw.	7.6	865	679.1	11.2	......	ssw.	11.2
8:36 a. m......	707.1	12.9	43	s.	7.6	1400	636.8	8.4	......	wsw.	11.2
8:48 a. m......	706.9	12.9	44	s.	7.2	1943	596.6	3.7	......	wsw.	16.8
9:08 a. m......	706.8	11.9	55	sw.	7.2	2595	549.4	− 0.9	......	wsw.	15.6
9:32 a. m......	706.5	12.4	49	sw.	7.6	3213	508.1	− 5.3	......	wsw.	15.6
10:07 a. m......	706.3	13.0	53	ssw.	3.6	3743	474.6	− 9.8	......	wsw.	14.9
10:12 a. m......	706.2	13.1	54	ssw.	3.6	3872	466.8	− 9.8	......	wsw.	15.6
10:20 a. m......	706.2	13.2	55	sw.	4.0	4132	451.2	−12.8	......	wsw.	15.5
11:18 a. m......	705.5	14.2	57	wsw.	5.8	4432	433.4	−13.0	......	wsw.	18.3
11:45 a. m......	705.1	13.9	58	w.	7.6	4717	417.1	−15.5	......	wsw.	15.6
12:07 p. m......	705.0	8.0	95	wnw.	23.2	526	705.0	8.0	95	wnw.	23.2
October 26:											
9:31 a. m......	712.5	8.8	73	wnw.	12.5	526	712.5	8.8	73	wnw.	12.5
9:38 a. m......	712.5	9.0	65	wnw.	11.6	940	677.5	3.0	......	wnw.	....
9:52 a. m......	712.5	9.2	60	nw.	13.9	1348	644.0	0.1	......	wnw.	....
10:03 a. m......	712.4	9.7	59	wnw.	11.6	1762	611.5	− 3.1	......	nw.	....
10:18 a. m......	712.4	10.2	57	wnw.	10.7	2070	588.2	− 4.1	......	nw.	....
10:21 a. m......	712.4	10.3	58	w.	10.7	2246	575.2	− 1.6	......	nw.	....
11:05 a. m......	712.3	11.4	53	nw.	10.7	3318	502.2	− 6.8	......	nw.	....
11:25 a. m......	712.2	12.2	53	wnw.	10.7	3629	482.7	− 9.7	......	nw.	....
11:47 a. m......	712.1	12.2	49	wnw.	12.1	4686	420.1	−15.3	......	nw.	....
2:59 p. m......	711.2	14.0	42	wnw.	12.5	526	711.2	14.0	42	wnw.	12.5
October 27:											
3:05 p. m......	706.3	13.5	71	ssw.	6.7	526	706.3	13.5	71	ssw.	6.7
3:15 p. m......	706.3	13.4	69	ssw.	7.2	1125	657.6	10.2	......	sw.	....
3:32 p. m......	706.3	13.4	69	s.	6.3	1709	612.8	6.0	......	sw.	....
3:43 p. m......	706.3	13.4	67	s.	6.7	2165	579.5	2.6	......	wsw.	....
4:25 p. m......	706.8	14.0	68	ssw.	10.3	1878	600.3	4.0	......	sw.	....
4:40 p. m......	707.0	10.5	91	wnw.	10.3	1028	665.4	7.2	......	wnw.	....
4:43 p. m......	707.0	10.2	94	wnw.	10.7	526	707.0	10.2	94	wnw.	10.7

October 25.—Nine kites were used; lifting surface, 56.7 sq. m. Wire out, 12000 m.; at maximum altitude, 11200 m.

St.-Cu., altitude about 2600 m., and A.-St., altitude about 3600 m., both from the west-southwest, covered the sky until 10:30 a. m., when St.-Cu. from the west appeared, increasing to 8/10 by 11:30 a. m. These clouds were comparatively low and were accompanied by heavy rain and high wind. Atmospheric potentials were unusually high. Light rain fell from 9:07 to 9:12 a. m. and heavy rain began at 11:51 a. m.

At 8 a. m. low pressure was central over the lower Lakes.

October 26.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 8900 m.; at maximum altitude.

At 10:36 a. m. there were 3/10 St.-Cu., at 2:03 p. m., 4/10 St.-Cu. and 1/10 Ci. At end of the flight there were 1/10 Ci, 2/10 A.-St. and a few Cu. Direction northwest at all times.

High pressure was central over the Southeastern States. Pressure was low off the Maine coast and over Iowa.

October 27.—Two kites were used; lifting surface, 10.8 sq. m. Wire out, 4000 m., at maximum altitude.

The sky was covered with A.-St. and St.-Cu. from the west until 4:20 p. m., with St.-Cu. from the west and St. from the southwest until 4:30 p. m. and with St. from the west thereafter. Light rain fell after 4:34 p. m. The head kite was in the clouds at intervals after 4:21 p. m.

Pressure was low over Lake Ontario and high over Florida.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m. Pressure.	Temperature.	Rel. hum.	Wind. Dir.	Wind. Velocity.	At different heights above sea. Height.	Pressure.	Temperature.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. October 28:	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
8:31 a. m.	711.1	2.0	70	wnw.	9.4	526	711.1	2.0	70	wnw.	9.4
8:42 a. m.	711.1	2.2	57	wnw.	11.2	818	685.4	− 3.6	......	wnw.	....
8:48 a. m.	711.1	2.2	52	wnw.	10.3	1324	642.8	− 6.4	......	wnw.	13.4
8:51 a. m.	711.1	2.2	58	wnw.	10.7	1348	641.0	− 4.8	......	wnw.	13.4
9:07 a. m.	711.1	2.3	57	wnw.	12.5	1774	607.1	− 7.1	......	nw.	....
9:25 a. m.	711.1	2.7	53	nnw.	10.7	2244	571.4	−10.7	......	nw.	....
9:36 a. m.	711.0	2.8	54	w.	9.8	2750	535.0	−12.7	......	wnw.	15.0
10:00 a. m.	711.0	3.3	53	w.	10.7	3314	496.6	−16.3	......	wnw.	13.4
11:23 a. m.	711.0	5.0	56	nw.	10.7	4136	444.8	−21.9	......	wsw.	20.3
12:06 p. m.	711.0	5.3	44	nw.	10.7	3034	515.9	−16.4	......	w.	....
12:22 p. m.	711.0	5.8	45	wnw.	9.8	2194	575.8	− 9.6	......	wnw.	....
12:41 p. m.	711.0	5.4	40	wnw.	12.5	1522	627.5	− 3.8	......	wnw.	....
12:44 p. m.	711.0	5.5	41	wnw.	9.8	1354	641.0	− 4.4	......	wnw.	....
1:07 p. m.	711.0	6.0	40	wnw.	10.3	954	674.3	− 1.4	......	wnw.	....
1:18 p. m.	711.1	5.8	37	wnw.	10.7	526	711.1	5.8	37	wnw.	10.7
October 29:											
12:01 p. m.	716.6	1.8	48	nw.	15.2	526	716.6	1.8	48	nw.	15.2
12:09 p. m.	716.6	1.9	51	nw.	15.2	840	689.1	− 2.0	......	nw.	....
12:19 p. m.	716.5	2.4	46	nw.	13.4	1243	654.7	− 5.1	......	nw.	....
12:30 p. m.	716.4	1.6	51	nw.	12.5	1489	634.2	− 7.5	......	nw.	....
12:49 p. m.	716.3	1.8	52	nw.	12.1	2007	593.2	−11.4	......	nw.	....
1:48 p. m.	716.4	3.0	46	nw.	15.2	2544	553.2	−14.9	......	nw.	....
2:11 p. m.	716.5	2.1	46	nw.	14.3	2992	521.1	−17.0	......	nw.	....
2:22 p. m.	716.6	2.2	46	nw.	14.3	2682	543.1	−14.8	......	nw.	....
2:46 p. m.	716.9	0.6	54	nw.	13.4	1815	608.4	−10.5	......	nw.	....
3:00 p. m.	717.1	0.8	61	nw.	10.7	1516	632.4	− 7.6	......	nw.	....
3:10 p. m.	717.1	0.6	66	nw.	10.3	1246	654.7	− 6.0	......	nw.	....
3:20 p. m.	717.1	0.4	65	nw.	10.3	844	689.1	−3.0	......	nw.	....
3:25 p. m.	717.1	0.7	65	nw.	11.2	526	717.1	0.7	65	nw.	11.2

October 28.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 9000 m.; at maximum altitude, 8100 m.

There were 1/10 to 2/10 Cu. from the west-northwest.

Pressure was low over the St. Lawrence Valley and the northeast and high over the western plains and mountain districts.

October 29.—Five kites were used; lifting surface, 27.0 sq. m. Wire out, 6500 m.; at maximum altitude, 5200 m.

There were 5/10 to 9/10 St.-Cu. from the northwest. Snow fell from 3:13 to 3:18. p. m. The head kite was in the clouds at intervals from 12:39 to 2:52 p. m.

Pressure was low off the Massachusetts coast and high over Louisiana.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Pressure.	Temperature.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910. October 30:	mm.	° C.	%		m. p. s.	m.	mm.	° C.	%		m. p. s.
7:01 a. m......	724.4	− 3.2	72	wnw.	8.9	526	724.4	− 3.2	72	wnw.	8.9
7:13 a. m......	724.5	− 3.0	74	wnw.	8.9	884	692.5	− 4.2	......	nw.	....
7:25 a. m......	724.7	− 2.6	74	wnw.	8.9	1348	652.8	− 7.0	......	nw.	....
7:33 a. m......	724.7	− 2.5	74	wnw.	8.9	1576	634.0	− 9.7	......	nnw.	....
7:36 a. m......	724.7	− 2.4	74	wnw.	8.9	1806	615.4	− 8.9	......	nw.	....
7:40 a. m......	724.8	− 2.4	74	wnw.	8.5	1830	613.6	− 9.7	......	nw.	....
7:44 a. m......	724.9	− 2.3	72	wnw.	8.5	1922	606.4	− 7.7	......	nw.	....
7:52 a. m......	725.0	− 2.2	71	wnw.	8.5	2291	578.4	− 9.1	......	nw.	....
8:48 a. m......	725.3	− 0.6	63	wnw.	8.5	2836	539.2	−11.4	......	nw.	....
9:17 a. m......	725.3	− 0.3	66	wnw.	9.8	3556	490.9	−13.4	......	nnw.	....
9:40 a. m......	725.3	0.3	62	wnw.	8.5	2839	539.2	−10.2	......	nnw.	....
9:52 a. m......	725.3	0.7	62	wnw.	7.6	2033	598.4	− 8.0	......	nw.	....
9:55 a. m......	725.3	0.9	62	wnw.	7.2	1839	613.6	− 9.7	......	nw.	....
10:00 a. m......	725.3	1.0	62	wnw.	6.7	1817	615.4	− 8.0	......	nw.	....
10:04 a. m......	725.3	1.0	61	wnw.	7.2	1749	620.8	− 9.4	......	nw.	....
10:17 a. m......	725.3	1.2	62	wnw.	7.6	1253	661.7	− 6.2	......	nw.	....
10:24 a. m......	725.3	1.5	65	wnw.	8.5	794	701.4	− 2.5	......	wnw.	....
10:29 a. m......	725.3	1.6	59	wnw.	8.5	526	725.3	1.6	59	wnw.	8.5
October 31:											
7:21 a. m......	722.9	6.8	37	wsw.	7.2	526	722.9	6.8	37	wsw.	7.2
7:28 a. m......	723.0	7.0	8	wsw.	7.6	872	693.2	4.9	......	wnw.	....
9:06 a. m......	723.4	8.6	38	w.	7.6	1593	634.8	2.4	......	nw.	....
9:08 a. m......	723.4	8.6	38	w.	7.6	1931	609.0	4.2	......	nw.	....
9:20 a. m......	723.4	8.7	38	w.	7.6	3760	484.9	− 3.7	......	wnw.	....
9:43 a. m......	723.3	9.2	38	w.	6.7	4438	444.8	− 8.5	......	wnw.	....
10:05 a. m......	723.3	9.7	38	w.	5.8	5160	405.1	−12.4	......	wnw.	....
12:46 p. m......	722.7	12.5	36	w.	4.0	5606	382.7	−14.7	......	nw.	....
1:30 p. m......	722.6	13.2	35	w.	4.0	5138	407.0	−11.6	......	nw.	....
1:49 p. m......	722.4	13.2	35	w.	5.4	4418	446.6	− 7.3	......	wnw.	....
2:04 p. m......	722.4	13.8	36	wnw.	4.5	3495	502.2	− 3.0	......	nw.	....
2:17 p. m......	722.4	13.8	36	w.	4.9	2834	545.5	1.1	......	nw	....
2:27 p. m......	722.4	13.8	34	w.	5.4	2011	603.5	6.1	......	nw.	....
2:42 p. m......	722.4	13.9	34	w.	4.0	1598	634.8	5.0	......	wnw.	....
2:47 p. m......	722.4	14.1	34	w.	4.0	1410	649.6	5.4	......	w.	....
2:54 p. m......	722.4	14.2	34	w.	4.0	526	722.4	14.2	34	w.	4.0

October 30.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 6600 m.; at maximum altitude, 4900 m.

The sky was cloudless at first; there were a few Ci.-St. from the northwest after 9 a. m. and a few Cu. from the northwest after 10 a.m.

At 8 a. m. pressure was low north of Lake Superior, and high over the southeastern States.

October 31.—Eight kites were used; lifting surface, 51.4 sq. m. Wire out, 9500 m., at maximum altitude.

The sky was cloudless.

At 8 a. m. high pressure, central over Georgia, covered the eastern part of the country. A small low was central over northern Texas.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910. November 1:	mm.	° C.	%		m. p. s.	m.	mm.	° C.	%		m. p. s.
1:09 p. m.	720.8	13.5	51	sse.	10.3	526	720.8	13.5	51	sse.	10.3
1:15 p. m.	720.7	13.2	36	sse.	9.8	874	691.3	8.5	......	s.	....
1:32 p. m.	720.4	13.2	39	sse.	12.1	1388	649.3	10.0	......	s.	....
1:54 p. m.	720.1	12.5	41	sse.	9.8	2539	564.3	2.3	......	ssw.	....
2:19 p. m.	720.0	12.7	43	sse.	10.7	3363	509.2	− 1.9	......	ssw.	....
2:48 p. m.	720.0	13.2	40	s.	8.9	3789	482.7	− 3.8	......	ssw.	....
3:18 p. m.	720.0	12.9	42	sse.	8.0	4056	466.4	− 5.8	......	ssw.	....
3:51 p. m.	719.9	12.5	46	sse.	8.9	4538	438.4	− 9.8	......	sw.	....
4:14 p. m.	719.8	12.4	45	sse.	8.0	3748	484.6	− 3.2	......	sw.	....
4:26 p. m.	719.6	12.1	47	sse.	7.6	3237	516.6	− 0.7	......	ssw.	....
4:41 p. m.	719.5	11.9	50	sse.	8.9	2656	555.2	1.1	......	ssw.	....
4:50 p. m.	719.4	11.6	48	sse.	8.5	2140	591.6	4.9	......	ssw.	....
5:05 p. m.	719.3	11.2	54	sse.	8.9	1349	651.1	7.5	......	sse.	....
5:07 p. m.	719.3	11.2	54	sse.	8.9	1055	674.9	6.5	......	sse.	....
5:10 p. m.	719.3	11.2	52	sse.	8.5	923	685.8	8.0	......	sse.	....
5:16 p. m.	719.3	10.7	49	sse.	7.6	526	719.3	10.7	49	sse.	7.6
November 2:											
7:06 a. m.	716.2	7.7	61	s.	6.7	526	716.2	7.7	61	s.	6.7
7:10 a. m.	716.2	7.7	62	s.	6.7	755	696.8	10.9	......	wsw.	....
7:16 a. m.	716.2	8.0	60	ssw.	6.7	926	682.6	9.4	......	wsw.	....
7:27 a. m.	716.2	8.5	57	ssw.	6.7	1676	623.4	5.8	......	wsw.	....
7:49 a. m.	716.2	9.2	54	ssw.	5.8	2481	564.6	0.8	......	sw.	....
8:10 a. m.	716.2	9.8	53	ssw.	4.5	3686	484.9	− 7.3	......	sw.	....
8:13 a. m.	716.2	9.9	53	ssw.	5.4	3826	476.1	− 7.1	......	sw.	....
8:38 a. m.	716.2	10.8	49	wsw.	3.6	4430	440.6	−10.3	......	sw.	....
8:55 a. m.	716.2	10.8	47	w.	4.9	5004	408.8	−12.7	......	sw.	....
9:00 a. m.	716.2	10.8	47	w.	4.5	526	716.2	10.8	47	w.	4.5

November 1.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 8500 m.; at maximum altitude, 7300 m.

There were 5/10 to 9/10 Ci.-St. from the west. Solar halo.

Pressure was high over New Hampshire and low over Wisconsin.

November 2.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 8600 m., at maximum altitude.

There were 8/10 to 10/10 A.-St. from the southwest at an altitude of 3700 m. Parhelia were observed at 7:16 a. m.

At 8 a. m. a low was central north of the lower Lakes and a high over Nebraska.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
November 3:	*mm.*	° *C.*	%		*m.p.s.*	*m.*	*mm.*	° *C.*	%		*m.p.s.*
8:50 a.m.	715.6	1.4	89	nw.	6.7	526	715.6	1.4	89	nw.	6.7
9:04 a.m.	715.6	1.8	88	nw.	6.7	866	685.8	− 2.4	......	n.	....
9:14 a.m.	715.5	1.8	86	nw.	10.3	1299	649.3	− 2.4	......	n.	....
9:27 a.m.	715.3	2.0	83	nw.	10.7	1888	602.5	− 5.3	......	n.	....
9:42 a.m.	715.2	2.2	78	nnw.	10.7	2451	560.7	− 8.3	......	n.	....
9:49 a.m.	715.1	2.2	80	nnw.	10.7	2668	545.1	−10.2	......	n.	....
10:06 a.m.	715.0	2.8	76	nw.	8.9	3084	516.5	−11.6	......	n.	....
11:41 a.m.	714.1	4.0	70	nw.	10.7	3457	491.3	−12.1	......	w.	....
12:05 p.m.	713.7	4.2	71	nw.	12.1	4347	436.5	−18.9	......	sw.	....
1:20 p.m.	713.0	4.1	66	nw.	15.2	5436	376.6	−23.7	......	s.	....
2:23 p.m.	712.8	3.8	71	nw.	16.1	4138	448.1	−14.5	......	sw.	....
2:30 p.m.	712.8	3.8	70	nw.	16.1	3925	460.8	−16.7	......	w.	....
2:40 p.m.	712.7	3.8	69	nw.	16.1	3487	488.2	−14.9	......	nnw.	....
3:19 p.m.	712.9	4.1	61	nw.	13.4	3086	514.7	−12.1	......	nnw.	....
3:40 p.m.	713.0	4.2	56	nw.	16.1	2354	566.1	− 7.8	......	nnw.	....
3:55 p.m.	713.0	4.1	57	nw.	15.6	1842	604.4	− 6.9	......	nnw.	....
4:39 p.m.	712.5	3.4	64	nw.	15.6	921	678.5	0.6	......	nnw.	....
4:41 p.m.	712.5	3.2	60	nw.	15.6	526	712.5	3.2	60	nw.	15.6
November 4:											
3:04 p.m.	710.2	2.8	72	nw.	21.5	526	710.2	2.8	72	nw.	21.5
3:14 p.m.	710.3	2.6	75	nw.	20.6	1082	662.8	−1.2	......	nw.	....
3:26 p.m.	710.4	2.8	72	nw.	19.7	1259	648.4	2.8	......	nnw.	....
3:42 p.m.	710.5	3.0	69	nw.	18.8	1902	598.2	1.3	......	nnw.	....
3:50 p.m.	710.5	3.2	69	nw.	22.4	526	710.5	3.2	69	nw.	22.4
November 5:											
10:17 a.m.	712.3	3.5	52	wnw.	16.1	526	712.3	3.5	52	wnw.	16.1
10:24 a.m.	712.3	3.7	51	wnw.	16.1	777	690.5	0.0	......	wnw.	....
10:34 a.m.	712.2	4.4	49	wnw.	15.2	893	680.7	10.0	......	nw.	....
11:56 a.m.	711.6	5.2	43	wnw.	13.9	1183	656.6	5.3	......	wnw.	....
12:05 p.m.	711.6	4.9	46	wnw.	14.3	936	676.6	8.9	......	wnw.	....
12:20 p.m.	711.6	5.5	44	wnw	15.2	886	680.7	2.0	......	wnw.	....
12:30 p.m.	711.6	6.4	41	wnw.	15.2	526	711.6	6.4	41	wnw.	15.2

November 3.—Nine kites were used; lifting surface, 57.2 sq. m. Wire out, 10900 m.; at maximum altitude, 10000 m.

7/10 A.-St. from the south gradually disappeared and a few St.-Cu. from the north-northwest at 9:48 a. m. increased to 3/10.

Pressure was low off the North Carolina coast and high from the Lakes to the Gulf.

November 4.—Two kites were used; lifting surface, 10.8 sq. m. Wire out, 4000 m., at maximum altitude.

There were 10/10 St. from the north-northwest. Light snow fell throughout.

Pressure was high north of Lake Huron and low off the New Jersey coast.

November 5.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 4000 m.; at maximum altitude, 3000 m.

There were 8/10 Ci.-St. and A.-St. from the west-northwest.

At 8 a. m. a well developed low was central off the New England coast. Pressure was relatively high from the Lake region southward to Florida.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
November 6:	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
10:02 a. m......	712.0	3.8	62	wnw.	9.8	526	712.0	3.8	62	wnw.	9.8
10:07 a. m......	712.0	3.6	61	wnw.	9.8	911	678.8	− 0.4	......	wnw.	....
10:20 a. m......	711.9	3.8	61	wnw.	8.9	1345	642.6	− 5.0	......	wnw.	....
10:42 a. m......	711.9	3.1	67	wnw.	7.2	1883	599.6	−10.5	......	wnw.	....
10:48 a. m......	711.8	3.0	68	wnw.	8.0	2210	574.8	− 7.1	......	w.	....
11:05 a. m......	711.8	2.9	69	nw.	8.0	2849	529.4	− 9.5	......	w.	....
11:36 a. m......	711.4	3.3	58	nw.	8.0	2995	519.3	− 5.6	......	w.	....
12:50 p. m......	710.7	3.1	50	nw.	9.8	4060	451.2	−15.3	......	wsw.	....
1:09 p. m......	710.6	3.4	52	wnw.	8.9	3287	498.9	− 8.3	......	w.	....
1:17 p. m......	710.5	2.9	46	wnw.	9.8	2856	527.4	−10.0	......	w.	....
1:37 p. m......	710.5	3.1	47	wnw.	8.9	2190	574.8	− 8.3	......	w.	....
1:38 p. m......	710.5	3.1	47	wnw.	8.9	1976	591.0	−10.0	......	w.	....
1:56 p. m......	710.4	3.0	46	wnw.	8.9	1275	646.6	− 5.9	......	w.	....
2:09 p. m......	710.4	3.0	45	wnw.	9.8	892	678.8	− 1.9	......	w.	....
2:19 p. m......	710.4	3.0	44	wnw.	9.8	526	710.4	3.0	44	wnw.	9.8
November 7:											
8:17 a. m......	712.6	−3.7	59	wnw.	7.6	526	712.6	− 3.7	59	wnw.	7.6
8:26 a. m......	712.6	−3.4	59	wnw.	8.9	892	680.1	− 7.9	......	wnw.	....
8:34 a. m......	712.6	−3.4	59	wnw.	7.6	1293	645.8	− 9.6	......	wnw.	....
8:39 a. m......	712.6	−3.2	59	wnw.	8.5	1444	633.4	− 7.9	......	wnw.	....
8:50 a. m......	712.5	−3.0	55	wnw.	8.0	1928	594.8	−12.3	......	wnw.	....
9:08 a. m......	712.4	−2.7	55	wnw.	8.9	2472	553.8	−15.1	......	wnw.	....
9:27 a. m......	712.2	−2.4	55	nw.	11.6	2994	516.5	−17.2	......	nw.	....
9:37 a. m......	712.1	−2.2	52	wnw.	10.3	3128	507.3	−15.5	......	nw.	....
9:40 a. m......	712.0	−2.0	51	wnw.	10.3	3228	501.2	−16.3	......	nw.	....
9:44 a. m......	712.0	−1.8	51	wnw.	10.7	3038	514.4	−15.6	......	nw.	....
9:50 a. m......	711.9	−1.7	51	wnw.	13.4	2920	522.6	−15.9	......	nw.	....
10:03 a. m......	711.8	−1.4	48	nw.	11.6	2762	533.6	−14.2	......	nw.	....
10:18 a. m......	711.8	−1.2	48	nw.	13.4	2506	551.8	−14.2	......	nw.	....
10:34 a. m......	711.7	−1.3	48	wnw.	8.9	2205	574.0	−11.9	......	nw.	....
10:56 a. m......	771.7	−0.7	45	wnw.	11.2	1750	608.9	− 8.3	......	nw.	....
11:30 a. m......	711.6	0.0	46	nnw.	7.2	1144	658.0	− 6.7	......	wnw.	....
11:43 a. m......	711.5	0.8	46	nw.	6.3	725	694.0	− 2.7	......	nw.	....
11:49 a. m......	711.5	0.4	46	nw.	7.2	526	711.5	0.4	46	nw.	7.2

November 6.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 7800 m.; at maximum altitude, 6500 m.

5/10 St. Cu. from the west-northwest increased to 8/10 by 10:30 a. m. and decreased to 1/10 by 11:46 a. m. A few A.-Cu. from the southwest appeared at 10:30 a. m. and increased to 8/10 by 11:46 a. m.

Low pressure was central over the Gulf of St. Lawrence and high pressure over Texas.

November 7.—Four kites were used; lifting surface 25.7 sq. m. Wire out, 6000 m., at maximum altitude.

There were a few Ci.-Cu. from the west-northwest, and Cu. from the northwest.

High pressure was central over the Gulf. Centers of low pressure lay over Nova Scotia and Wisconsin.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
November 8:	*mm.*	*° C.*	*%*		*m. p. s.*	*m.*	*mm.*	*° C.*	*%*		*m. p. s.*
7:21 a. m......	706.4	6.2	55	w.	7.6	526	706.4	6.2	55	w.	7.6
7:28 a. m......	706.4	5.2	62	w.	7.6	922	673.0	5.9	......	w.	....
7:34 a. m......	706.4	5.0	62	w.	7.6	1347	638.7	1.5	......	w.	....
7:46 a. m......	706.5	4.8	63	w.	9.4	1745	607.8	− 2.3	......	w.	....
7:56 a. m......	706.5	4.8	63	wnw.	8.5	2264	568.9	− 8.5	......	w.	....
8:50 a. m......	706.8	5.1	63	wnw.	9.4	2796	530.5	−11.9	......	w.	....
10:02 a. m......	707.6	7.5	51	wnw.	17.4	2232	570.9	− 9.1	......	wnw.	....
10:38 a. m......	707.7	6.2	60	wnw.	17.9	1685	612.3	− 6.0	......	wnw.	....
10:56 a. m......	707.7	6.1	59	wnw.	25.0	1299	643.0	− 1.9	......	wnw.	....
11:13 a. m......	707.8	6.2	50	wnw.	25.0	934	673.0	1.0	......	wnw.	....
11:30 a. m......	708.0	5.8	51	wnw.	16.1	526	708.0	5.8	51	wnw.	16.1
November 9:											
1:05 p. m......	713.7	10.0	42	s.	6.7	526	713.7	10.0	42	s.	6.7
1:16 p. m......	713.6	10.4	40	s.	7.6	955	677.8	10.3	......	wsw.	....
1:25 p. m......	713.4	11.0	38	s.	7.6	1462	637.6	7.6	......	w.	....
1:36 p. m......	713.1	11.5	39	s.	7.2	1975	598.6	3.4	......	w.	....
1:52 p. m......	713.0	11.2	36	s.	7.6	2402	567.7	1.4	......	w.	....
2:14 p. m......	712.9	12.5	37	s.	8.0	2978	528.4	− 2.6	......	w.	....
2:34 p. m......	712.9	12.7	38	s.	7.6	3192	514.2	− 4.6	......	w.	....
2:44 p. m......	712.9	12.8	40	s.	7.2	3543	491.8	− 7.2	......	w.	....
3:06 p. m......	712.9	11.7	40	s.	7.6	4011	462.7	−12.2	......	w.	....
3:31 p. m......	712.9	11.7	42	s.	8.0	2980	528.4	− 2.3	......	w.	....
3:43 p. m......	712.9	11.8	41	s.	7.2	2404	567.7	2.1	......	w.	....
3:58 p. m......	712.9	11.7	43	sse.	8.0	1891	604.6	3.9	......	w.	....
4:09 p. m......	712.9	11.8	40	sse.	8.0	1458	637.6	7.4	......	wsw.	....
4:23 p. m......	712.8	11.6	40	sse.	8.5	948	677.8	11.7	......	sw.	....
4:29 p. m......	712.8	11.5	40	sse.	7.6	526	712.8	11.5	40	sse.	7.6
November 10:											
8:16 a. m......	708.2	14.2	36	ssw.	6.3	526	708.2	14.2	36	ssw.	6.3
8:40 a. m......	707.7	14.2	37	ssw.	6.3	881	678.5	11.8	......	ssw.	....
8:54 a. m......	707.5	14.4	37	ssw.	6.7	1404	637.1	9.0	......	ssw.	....
9:05 a. m......	707.5	15.3	38	ssw.	6.3	1905	599.7	6.6	......	ssw.	....
9:10 a. m......	707.4	14.4	37	ssw.	6.3	2141	582.7	6.6	......	ssw.	....
9:38 a. m......	707.0	15.2	38	ssw.	6.7	3006	523.5	− 0.2	......	sw.	....
10:16 a. m......	706.6	15.4	37	ssw.	5.4	3930	462.8	− 8.2	......	sw.	....
10:43 a. m......	706.4	14.3	42	sw.	7.6	3004	521.6	− 1.7	......	wsw.	....
11:02 a. m......	706.3	14.1	41	sw.	6.7	2063	586.4	2.8	......	wsw.	....
11:36 a. m......	706.0	14.4	45	wsw.	6.7	1699	612.9	4.2	......	wsw.	....
12:39 p. m......	705.5	14.7	48	sw.	11.6	1239	647.8	7.3	......	sw.	....
12:55 p. m......	705.3	14.4	48	wsw.	8.9	526	705.3	14.4	48	wsw.	8.9

November 8.—Four kites were used; lifting surface, 25.2 sq. m. Wire out 6000 m.; at maximum altitude, 5900 m.

There were 2/10 to 7/10 St.-Cu. from the west at an altitude of 2300 m.

At 8 a. m. low pressure was central over eastern Pennsylvania and comparatively high pressure extended from the upper Lakes to the Gulf of Mexico.

November 9.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 7500 m.; at maximum altitude, 6900 m.

There were 2/10 to 8/10 A.-Cu. from the west.

Pressure was high over North Carolina and low over the Gulf of St. Lawrence.

November 10.—Five kites were used; lifting surface, 32.0 sq. m. Wire out, 9000 m.; at maximum altitude, 8900 m.

A.-Cu. from the west-southwest diminished from 8/10 at 8 a. m. to 1/10 by 10:15 a. m., when St.-Cu., also from the west-southwest, appeared. The latter, altitude 3400 m., soon covered the sky, but gradually diminished after 12 m. Light rain fell between 10 a. m. and 12 m.

At 8 a. m. a very active low was central over the lower Lakes.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
November 11:	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
8:11 a. m.	708.0	2.1	55	w.	9.4	526	708.0	2.1	55	w.	9.4
8:21 a. m.	708.0	2.2	55	w.	8.9	912	674.7	− 1.2	......	w.	......
8:31 a. m.	708.1	2.4	54	w.	8.9	1444	631.0	− 5.0	......	w.	......
8:43 a. m.	708.1	2.4	55	w.	9.4	1869	597.6	− 8.7	......	w.	......
9:01 a. m.	708.1	2.4	53	w.	11.6	2360	560.6	− 12.3	......	w.	......
9:23 a. m.	707.9	2.6	54	w.	8.5	2908	521.4	− 16.3	......	w.	......
9:31 a. m.	707.9	2.8	55	w.	8.9	3044	512.2	− 18.8	......	w.	......
10:58 a. m.	707.4	4.2	45	w.	10.7	3838	460.7	− 17.0	...	w.	......
11:39 a. m.	707.0	3.3	48	w.	17.0	3240	498.3	− 15.5	......	w.	......
11:44 a. m.	706.9	3.5	46	w.	17.0	2924	519.5	− 16.4	......	w.	......
12:10 p. m.	706.7	4.0	41	w.	15.6	2345	560.6	− 12.7	......	w.	......
12:16 p. m.	706.7	3.6	43	w.	15.2	1782	603.0	− 9.5	......	w.	......
12:30 p. m.	706.8	0.1	97	nw.	14.8	1240	645.7	− 6.2	......	wnw.	......
12:45 p. m.	706.9	− 1.2	98	nw.	10.3	936	671.2	− 4.3	......	nw.	......
12:56 p. m.	706.9	− 0.6	88	nw.	9.4	526	706.9	− 0.6	88	nw.	9.4
November 12:											
3:55 p. m.	708.2	0.8	62	wnw.	21.5	526	708.2	0.8	62	wnw.	21.5
4:05 p. m.	708.2	0.6	62	wnw.	20.6	879	677.5	− 2.8	......	wnw.	......
4:15 p. m.	708.2	0.6	61	wnw.	22.4	1155	654.2	− 6.3	......	wnw.	......
4:32 p. m.	708.2	0.6	61	wnw.	24.1	1584	619.1	− 8.8	......	nw.	......
4:50 p. m.	708.2	0.6	61	wnw.	21.5	1196	650.7	− 6.3	......	wnw.	......
5:03 p. m.	708.2	0.5	63	wnw.	23.2	879	677.5	− 3.3	......	wnw.	......
5:09 p. m.	708.2	0.5	63	wnw.	21.5	526	708.2	0.5	63	wnw.	21.5
November 13:											
11:28 a. m.	709.9	0.3	60	nw.	15.6	526	709.9	0.3	60	nw.	15.6
11:36 a. m.	709.8	0.5	56	nw.	17.0	893	677.8	− 4.0	......	wnw.	......
11:50 a. m.	709.6	1.1	52	wnw.	19.7	1197	651.8	− 7.9	......	wnw.	......
12:16 p. m.	709.4	0.8	52	nw.	21.5	1772	604.6	−13.7	......	wnw.	......
12:43 p. m.	709.4	0.6	58	wnw.	19.7	1363	637.6	−10.0	......	wnw.	......
1:11 p. m.	709.0	0.5	56	wnw.	22.4	746	689.7	− 3.6	......	wnw.	......
1:16 p. m.	708.9	0.5	56	wnw.	24.1	526	708.9	0.5	56	wnw.	24.1

November 11.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 9700 m.; at maximum altitude, 9000 m.

There were 7/10 to 10/10 St.-Cu. from the west, altitude diminishing from 2600 to 2100 m., until about 12:15 p. m., when they were quickly obscured by St.-Cu. from the northwest, altitude 1000 m. Occasional light snow flurries occurred between 9 a. m. and 1 p. m.

At 8 a. m. low pressure was central north of the lower Lakes and high pressure over the Dakotas and Minnesota.

November 12.—One kite was used; lifting surface, 5.4 sq. m. Wire out, 2500 m., at maximum altitude.

There were 8/10 St.-Cu. from the west-northwest at an altitude of 1100 m.

Pressure was low over New York and high over Manitoba.

November 13.—Two kites were used; lifting surface, 10.8 sq. m. Wire out, 4000 m.; at maximum altitude, 3800 m.

The sky was covered with St.-Cu. from the west-northwest. The head kite was hidden by St.-Cu. at 11:55 a. m., and from 12:04 to 12:35 p. m.; altitude of cloud base about 1500 m.

Low pressure was central over Maine and Oklahoma. Pressure was high over Minnesota.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
November 14:	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
7:40 a. m.	709.2	0.2	67	wnw.	11.6	526	709.2	0.2	67	wnw.	11.6
7:48 a. m.	709.2	0.2	64	wnw.	10.3	858	680.3	−3.0	......	wnw.	....
8:02 a. m.	709.2	0.2	64	wnw.	11.2	1095	660.1	−4.8	......	nw.	....
8:09 a. m.	709.2	0.2	64	wnw.	10.3	1621	617.6	−3.1	......	nw.	....
8:20 a. m.	709.2	0.4	64	nw.	4.9	2059	584.3	−4.1	......	nw	....
8:56 a. m.	709.2	1.0	62	w	6.3	2225	572.2	−3.1	......	wnw.	....
9:27 a. m.	709.2	1.8	61	w.	6.3	2881	526.8	−5.9	......	wnw.	....
9:46 a. m.	709.2	2.6	57	sw.	5.8	[illegible]	535.8	−3.1	......	wnw.	....
10:27 a. m.	708.8	2.3	60	w.	3.1	1914	595.0	−4.1	......	wnw.	....
10:32 a. m.	708.8	2.6	58	w.	3.1	1808	[illegible]	−3.4	......	wnw.	....
10:35 a. m.	708.3	2.6	58	w.	3.6	1357	[illegible]	−6.3	......	wnw.	....
12:04 p. m.	707.4	3.1	54	s.	4.0	526	707.4	3.1	54	s.	4.0
November 15:											
10:22 a. m.	710.4	1.2	62	wnw.	12.5	526	710.4	1.2	62	wnw.	12.5
10:27 a. m.	710.4	1.0	62	wnw.	12.5	910	677.0	− 3.0	......	wnw.	....
10:50 a. m.	710.4	1.0	64	wnw.	13.4	1493	628.3	− 9.9	......	wnw.	....
11:08 a. m.	710.4	2.1	58	wnw.	16.1	2226	570.9	−14.5	......	nw.	....
11:47 a. m.	710.4	1.8	65	wnw.	13.4	2526	548.7	−18.3	......	w.	....
11:58 a. m.	710.4	1.6	69	wnw.	11.6	2727	534.5	−12.0	......	w.	....
12:02 p. m.	710.4	1.8	65	wnw.	11.6	2450	554.7	−16.6	......	w.	....
12:21 p. m.	710.4	2.0	60	wnw.	9.8	2181	574.9	−14.2	......	nw.	....
12:30 p. m.	710.4	2.0	61	wnw.	11.6	1856	599.7	−11.6	......	nw.	....
12:43 p. m.	710.4	2.1	61	wnw.	12.5	1321	642.7	− 7.0	......	nw.	....
1:00 p. m.	710.4	2.5	58	wnw.	13.9	889	679.0	− 2.1	......	wnw.	....
1:07 p. m.	710.4	2.6	53	wnw.	13.4	526	710.4	2.6	53	wnw.	13.4
November 16:											
1:16 p. m.	713.1	1.2	79	wnw.	13.0	526	713.1	1.2	79	wnw.	13.0
1:23 p. m.	713.1	1.2	72	wnw.	13.4	932	677.8	− 3.6	......	wnw.	....
1:33 p. m.	713.1	1.2	66	wnw.	13.4	1190	655.7	− 7.0	......	nw.	....
1:55 p. m.	713.2	1.2	68	wnw.	12.5	1588	623.1	− 9.9	......	wnw.	....
2:29 p. m.	713.3	1.3	66	wnw.	13.9	1747	610.6	−10.7	......	wnw.	....
2:47 p. m.	713.4	1.4	65	wnw.	11.6	2635	545.4	0.5	......	wnw.	....
2:53 p. m.	713.4	1.3	65	wnw.	....	2453	557.6	1.9	......	wnw.	....
3:20 p. m.	713.5	1.2	66	wnw.	16.5	1898	598.5	−11.0	......	wnw.	....
3:39 p. m.	713.5	1.2	69	wnw.	13.4	1586	623.1	−10.5	......	wnw.	....
3:55 p. m.	713.6	1.0	66	wnw.	17.4	1340	643.5	− 8.4	......	nw.	....
4:10 p. m.	713.6	1.0	66	wnw.	13.4	959	675.7	− 5.7	......	wnw.	....
4:25 p. m.	713.6	0.8	66	wnw.	13.9	526	713.6	0.8	66	wnw.	13.9

November 14.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 5250 m.; at maximum altitude, 4500 m.

A.-Cu. and St.-Cu., moving from the west-northwest, covered 5/10 to 9/10 of the sky.

Pressure was low over Nova Scotia, with a secondary depression over Kentucky, and was relatively high over Florida.

November 15.—Four kites were used; lifting surface, 24.3 sq. m. Wire out, 5500 m.; at maximum altitude, 5300 m.

The sky was nearly overcast with St.-Cu., one layer from the west-northwest at an altitude of 1400 m. and another layer from the northwest at an altitude of 2400 m.

At 8 a. m. pressure was high over the upper Mississippi Valley and low over the Gulf of St. Lawrence.

November 16.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 5500 m.; at maximum altitude, 5000 m.

The sky was covered with St.-Cu., from the west-northwest until near the end of the flight, then from the northwest. The head kite was hidden by clouds from 1:38 to 3:53 p. m.; altitude of cloud base was about 1300 m.

Low pressure was central over the Gulf of St. Lawrence. Pressure was high over the Mississippi Valley.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
November 17:	*mm.*	° *C.*	%		*m.p.s.*	*m.*	*mm.*	° *C.*	%		*m.p.s.*
1:44 p. m.	712.8	0.8	70	nw.	20.6	526	712.8	0.8	70	nw.	20.6
1:50 p. m.	712.8	0.7	72	wnw.	19.7	852	684.3	−2.0	......	nw.	....
2:01 p. m.	712.7	0.7	69	wnw.	18.8	976	673.7	−4.0	......	nw.	....
2:23 p. m.	712.5	1.1	70	wnw.	19.7	1127	660.9	5.4	......	nw.	....
3:05 p. m.	712.3	0.1	73	wnw.	18.8	1396	639.3	3.2	......	nw.	....
3:25 p. m.	712.2	0.4	71	nw.	19.7	1857	603.7	1.0	......	nw.	....
3:36 p. m.	712.2	0.0	76	nw.	18.8	1661	618.7	2.3	......	nw.	....
3:47 p. m.	712.1	−0.2	66	wnw.	20.6	1098	662.9	5.6	......	nw.	....
4:06 p. m.	712.1	−0.3	76	nw.	18.8	864	682.5	−3.9	......	nw.	....
4:11 p. m.	712.1	−0.3	76	nw.	17.9	526	712.1	−0.3	76	nw.	17.9
November 18:											
8:32 a. m.	712.9	−1.3	82	nw.	7.6	526	712.9	− 1.3	82	nw.	7.6
8:40 a. m.	712.9	−1.3	82	nw.	6.7	847	684.7	− 4.4	......	wnw.	....
8:53 a. m.	713.0	−1.2	76	nw.	6.3	1386	639.3	− 6.1	......	w.	....
9:02 a. m.	713.0	−1.0	72	nw.	6.7	1580	623.8	− 1.7	......	w.	....
9:32 a. m.	713.2	−0.6	70	nw.	6.7	2043	588.7	− 3.0	......	wnw.	....
9:50 a. m.	713.3	−0.1	68	wnw.	5.4	2560	551.4	− 6.6	......	wnw.	....
10:38 a. m.	713.6	0.8	62	wnw.	5.4	3449	492.2	− 8.3	......	w.	....
11:32 a. m.	713.8	2.1	64	nw.	5.4	4334	439.2	−12.3	......	w.	....
11:52 a. m.	713.9	2.5	62	wnw.	5.4	3865	467.2	−10.6	......	wsw.	....
12:17 p. m.	713.7	3.0	57	w.	5.4	2840	533.1	− 7.0	......	w.	....
12:28 p. m.	713.4	3.3	53	w.	6.7	2280	572.3	− 3.9	......	w.	....
12:55 p. m.	713.0	3.6	52	w.	6.7	1542	628.0	− 3.0	......	w.	....
1:03 p. m.	713.0	3.4	......	nw.	4.5	1356	642.8	− 3.6	......	w.	....
1:11 p. m.	713.1	3.9	52	wnw.	4.5	526	713.1	3.9	52	wnw.	4.5
November 19:											
7:19 a. m.	717.3	−0.4	66	nw.	10.7	526	717.3	− 0.4	66	nw.	10.7
7:27 a. m.	717.3	−0.7	66	nw.	9.8	885	685.7	− 3.5	......	wnw.	....
7:45 a. m.	717.3	−0.8	80	nw.	7.2	1494	634.4	− 8.4	......	wnw.	....
7:57 a. m.	717.3	−0.8	80	nw.	16.5	1614	624.8	− 1.2	......	wnw.	....
8:05 a. m.	717.3	−0.8	82	nw.	16.5	2002	595.2	− 1.2	......	wnw.	....
8:21 a. m.	717.4	−0.8	70	nw.	7.6	2502	558.8	− 5.3	......	wnw.	....
8:50 a. m.	717.5	−0.4	58	nw.	6.3	3428	496.8	− 6.4	......	wnw.	....
9:15 a. m.	717.6	−0.3	64	nw.	5.8	3889	468.2	− 9.1	......	wnw.	....
9:39 a. m.	717.6	−0.1	62	nw.	6.7	4133	453.7	−10.2	......	wnw.	....
10:23 a. m.	717.7	0.2	61	nw.	10.7	4639	425.2	−14.0	......	wnw.	....
11:20 a. m.	717.6	0.8	56	nw.	10.7	3974	464.5	− 9.1	......	wnw.	....
11:44 a. m.	717.6	0.9	55	nw.	8.0	3144	516.5	− 4.9	......	nw.	....
12:07 p. m.	717.5	1.3	53	nw.	6.3	2316	573.3	− 0.4	......	nw.	....
12:25 p. m.	717.5	1.6	57	nw.	8.0	1430	640.3	− 0.6	......	nw.	....
12:29 p. m.	717.5	1.9	61	nw.	8.0	1272	653.2	− 5.1	......	nw.	....
12:38 p. m.	717.5	1.8	52	nw.	8.5	910	683.9	− 2.8	......	nw.	....
12:47 p. m.	717.5	1.5	52	nw.	9.8	526	717.5	1.5	52	nw.	9.8

November 17.—Four kites were used; lifting surface, 21.6 sq. m. Wire out, 4400 m.; at maximum altitude, 3400 m.

There were 6/10 to 7/10 St.-Cu. from the northwest throughout and 1/10 to 2/10 Ci.-Cu. from the northwest after 2:29 p. m. The head kite was in the St.-Cu. at intervals from 2:09 to 3:38 p. m.

Pressure was low over the Gulf of St. Lawrence and high over Illinois.

November 18.—Six kites were used; lifting surface 37.8 sq. m. Wire out, 7500 m.; at maximum altitude, 6500 m.

There were 4/10 to few St.-Cu. from the northwest until 9:10 a. m. There was 1/10 St.-Cu. from the northwest at 10:55 a. m.

The pressure was low over the Provinces of Quebec and New Brunswick and over the Gulf of Mexico. Pressure was high over the western plains States.

November 19.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 10000 m.; at maximum altitude, 9600 m.

There were 8/10 to a few St.-Cu. from the west-northwest until 9:36 a. m. and 1/10 to 7/10 A.-St. from the west after 8:58 a. m. The head kite was in the clouds at intervals from 7:38 a. m. to 12:36 p. m.

Pressure was high over Indiana and low over Nova Scotia.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Temperature.	Pressure.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
November 20:	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
3:28 p. m.....	718.4	5.0	59	se.	2.7	526	718.4	5.0	95	se.	2.7
3:57 p. m.....	718.4	5.5	49	e.	6.3	2455	566.5	0.1	......	wnw.	....
4:12 p. m.....	718.4	4.8	49	e.	4.0	1871	609.0	2.4	......	w.	....
4:22 p. m.....	718.4	4.3	48	e.	4.0	1436	642.4	4.2	......	wsw.	....
4:32 p. m.....	718.5	3.5	50	e.	4.0	1029	675.4	3.6	......	o.	....
4:40 p. m.....	718.5	2.7	52	se.	4.9	526	718.5	2.7	52	se.	4.9
November 21:											
First flight—											
8:34 a. m....	716.7	0.2	74	s.	7.2	526	716.7	0.2	74	s.	7.2
9:20 a. m....	716.6	1.0	66	s.	5.8	889	685.3	5.0	......	sw.	....
9:29 a. m....	716.6	1.2	66	sse.	5.8	1170	661.9	3.4	......	wsw.	....
9:34 a. m....	716.7	1.6	68	sse.	5.8	869	687.0	4.0	......	sw.	....
9:43 a. m....	716.8	1.9	68	sse.	4.9	526	716.8	1.9	68	sse.	4.9
Second flight—											
1:11 p. m....	713.8	5.3	56	sse.	8.0	526	713.8	5.3	56	sse.	8.0
1:12 p. m....	713.8	5.3	56	sse.	8.0	607	706.6	3.3	......	sse.	....
1:16 p. m....	713.8	5.5	56	sse.	8.0	834	687.3	6.1	......	s.	....
1:32 p. m....	713.7	5.2	55	sse.	6.7	1272	651.2	2.4	......	sw.	....
1:43 p. m....	713.6	5.4	54	sse.	7.6	1576	627.1	0.6	......	sw.	....
2:13 p. m....	713.5	6.5	64	sse.	8.5	2438	562.4	− 6.1	......	wsw.	....
2:24 p. m....	713.4	6.2	60	sse.	8.9	2936	526.8	− 8.6	......	wsw.	....
2:31 p. m....	713.4	6.1	52	sse.	7.6	3208	509.3	− 8.1	......	wsw.	....
2:38 p. m....	713.4	6.1	55	sse.	7.6	3026	521.3	− 9.1	......	wsw.	....
2:55 p. m....	713.3	5.8	55	sse.	7.2	2458	560.6	− 6.8	......	wsw.	....
3:08 p. m....	713.3	5.7	57	sse.	6.7	1859	604.9	− 2.8	......	wsw.	....
3:22 p. m....	713.2	5.7	57	sse.	7.6	1378	642.3	1.4	......	sw.	....
3:32 p. m....	713.1	5.6	57	sse.	6.3	911	680.3	5.6	......	sw.	....
3:37 p. m....	713.1	5.6	57	sse.	6.7	641	703.1	4.2	......	ssw.	....
3:42 p. m....	713.1	5.6	57	sse.	7.6	526	713.1	5.6	57	sse.	7.6
November 22:											
1:22 p. m.....	712.7	0.0	100	nw.	10.7	526	712.7	0.0	100	nw.	10.7
1:28 p. m.....	712.7	0.0	100	nw.	10.7	856	683.9	−2.0	......	nnw.	....
1:41 p. m.....	712.8	0.0	100	nw.	10.7	1290	647.4	−5.3	......	nnw.	....
1:54 p. m.....	713.0	0.0	100	nw.	10.7	1662	617.6	−6.7	......	nw.	....
2:10 p. m.....	713.1	0.2	100	nw.	10.7	1756	610.4	−6.0	......	nw.	....
2:22 p. m.....	713.2	0.3	100	nw.	12.5	1522	629.0	−5.8	......	nw.	....
2:38 p. m.....	713.3	0.4	100	nw.	11.6	1203	655.0	−4.0	......	nw.	....
2:51 p. m.....	713.4	0.6	96	wnw.	13.4	863	683.9	−1.8	......	nw.	....
2:59 p. m.....	713.5	0.7	98	nw.	11.6	526	713.5	0.7	98	nw.	11.6

November 20.—One captive ballon was used; capacity, 22.4 cu. m. Wire out, 2400 m.

The sky was cloudless.

Pressure was high over New York and low over Minnesota.

November 21.—First flight: Three kites were used; lifting surface, 18.9 sq. m. Wire out, 1700 m.; at maximum altitude, 1300 m.

There was 1/10 St.-Cu. from the west-southwest.

Second flight: Five kites were used; lifting surface, 31.5 sq. m. Wire out, 4500 m.; at maximum altitude, 4300 m.

The sky was covered with A.-St. from the west-southwest at an altitude of 3000 m.

At 8 a. m. pressure was high from New England to the Gulf of Mexico and a low was central over Lake Superior.

November 22.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 3000 m.; at maximum altitude, 2500 m.

Fog and light snow prevailed at the beginning. There were 1/10 A.-Cu. and 1/10 low St. from the northwest at the end of the flight.

Pressure was low over the Middle Atlantic and New England States and Manitoba and high over the Ohio Valley.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
November 23:	*mm.*	°C.	%		*m.p.s.*	*m.*	*mm.*	°C.	%		*m.p.s.*
1:24 p. m.....	714.7	4.9	60	se.	9.4	526	714.7	4.9	60	se.	9.4
1:36 p. m.....	714.7	4.6	67	se.	11.2	825	688.8	0.5	......	sse.	....
2:36 p. m.....	714.1	5.4	54	se.	8.5	1053	669.2	8.0	......	ssw.	....
3:45 p. m.....	713.5	3.9	60	se.	14.8	2466	562.3	1.6	......	sw.	....
3:55 p. m.....	713.4	3.8	61	se.	14.3	2989	526.7	−2.1	......	wsw.	....
4:18 p. m.....	713.3	3.4	64	se.	10.7	4067	459.2	−7.0	......	wsw.	....
4:44 p. m.....	713.2	3.2	57	sse.	10.3	3093	519.4	−2.5	......	wsw.	....
5:02 p. m.....	713.1	3.2	59	sse.	9.8	2356	569.6	1.0	......	wsw.	....
5:14 p. m.....	713.1	2.9	61	sse.	9.4	1870	604.7	4.5	......	wsw.	....
5:27 p. m.....	713.1	2.8	63	se.	10.3	1217	654.8	7.0	......	ssw.	....
5:34 p. m.....	713.1	2.8	63	se.	10.3	869	683.5	1.5	......	s.	....
5:40 p. m.....	713.1	2.6	63	se.	9.8	526	713.1	2.6	63	se.	9.8
November 24:											
8:12 a. m......	714.1	5.6	57	wnw.	4.9	526	714.1	5.6	57	wnw.	4.9
8:16 a. m......	714.1	5.8	56	wnw.	4.9	628	705.3	6.1	......	wnw.	....
8:23 a. m......	714.2	5.9	54	wnw.	5.4	860	685.7	4.2	......	wnw.	....
8:28 a. m......	714.2	5.9	55	wnw.	5.4	1030	671.4	2.6	......	wnw.	....
8:36 a. m......	714.2	5.9	56	wnw.	5.4	1392	642.1	3.6	......	wnw.	....
8:48 a. m......	714.3	6.0	55	wnw.	5.4	1874	605.1	1.2	......	nw.	....
8:57 a. m......	714.3	6.1	56	wnw.	5.4	2303	573.5	−0.6	......	nw.	....
9:10 a. m......	714.3	6.1	56	wnw.	5.4	526	714.3	6.1	56	wnw.	5.4
November 25:											
2:23 p. m......	709.3	5.3	71	wnw.	17.9	526	709.3	5.3	71	wnw.	17.9
2:27 p. m......	709.4	5.2	71	wnw.	19.7	878	679.3	1.2	......	nw.	....
2:43 p. m......	709.6	5.0	75	wnw.	17.0	1241	649.3	−2.5	......	nw.	....
2:54 p. m......	709.7	5.0	70	wnw.	18.8	1499	628.6	−4.2	......	nw.	....
3:02 p. m......	709.9	4.8	72	wnw.	17.0	1788	606.1	−3.5	......	nw.	....
3:18 p. m......	710.0	4.6	72	wnw.	17.0	2009	589.4	−4.3	......	nw.	....
3:25 p. m......	710.2	4.4	71	wnw.	16.0	1787	606.1	−3.3	......	nw.	....
3:28 p. m......	710.2	4.2	71	wnw.	14.3	1683	614.1	−5.5	......	nw.	....
3:53 p. m......	710.5	4.4	75	wnw.	16.1	1127	659.2	−2.1	......	nw.	....
4:09 p. m......	710.6	4.2	71	wnw.	15.2	1082	663.1	−1.6	......	nw.	....
4:19 p. m......	710.6	4.3	81	wnw.	11.9	866	681.3	0.2	......	nw.	....
4:26 p. m......	710.7	4.3	70	wnw.	17.0	526	710.7	4.3	70	wnw.	17.0

November 23.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 6000 m.; at maximum altitude, 5900 m.

There were 3/10 to 8/10 A.-Cu. from the west.

Pressure was high over Virginia and low over Lake Superior.

November 24.—Three kites were used; lifting surface, 23.8 sq. m. Wire out, 3000 m., at maximum altitude.

There were about 2/10 Ci.-St. from the northwest.

Lows were central over Minnesota and Iowa and north of the Lower Lakes and a moderate high over Florida.

November 25.—Three kites were used; lifting surface, 16.2 sq. m. Wire out, 4500 m.; at maximum altitude, 4000 m.

7/10 St.-Cu. from the northwest at the beginning had decreased to 6/10 by the end of the flight.

A low pressure area was central off the New Jersey coast. Pressure was comparatively high over the great central valleys.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
November 26:	*mm.*	° *C.*	%		*m.p.s.*	*m.*	*mm.*	° *C.*	%		*m.p.s.*
9:53 a. m......	715.0	1.4	53	nw.	16.1	526	715.0	1.4	53	nw.	16.1
10:08 a. m......	714.9	1.8	55	nw.	17.4	1117	663.4	−4.4	......	nw.	....
10:18 a. m......	714.8	1.6	57	nw.	16.5	1408	639.8	−1.0	......	nnw.	....
10:35 a. m......	714.6	1.8	61	nw.	16.5	2186	580.0	−4.0	......	n.	....
10:41 a. m......	714.6	1.8	61	nw.	16.5	2438	561.8	−2.2	......	n.	....
10:56 a. m......	714.4	2.0	56	nw.	16.1	3064	518.9	−5.5	......	nnw.	....
11:06 a. m......	714.4	1.9	58	nw.	17.0	3202	509.8	−7.0	......	nnw.	....
11:30 a. m......	714.4	2.0	58	nw.	16.5	2824	535.4	−4.5	......	nnw.	....
11:40 a. m......	714.3	2.5	64	nw.	17.0	2417	563.6	−2.9	......	nnw.	....
11:50 a. m......	714.3	2.4	54	nw.	18.8	2216	578.2	−3.6	......	nnw.	....
12:00 m........	714.3	2.4	55	nw.	17.9	1962	597.0	−2.7	......	nnw.	....
12:11 p. m.....	714.3	2.5	56	nw.	16.5	1765	612.0	−2.5	......	nnw.	....
12:20 p. m.....	714.3	2.6	57	nw.	15.2	1141	661.6	−1.8	......	nnw.	....
12:30 p. m.....	714.3	2.8	58	nw.	14.3	907	681.2	−1.4	......	nw.	....
12:46 p. m.....	714.3	3.0	51	nw.	15.6	526	714.3	3.0	51	nw.	15.6
November 27:											
3:58 p. m.....	711.7	3.0	63	ese.	3.1	526	711.7	3.0	63	ese.	3.1
4:14 p. m.....	711.6	3.1	64	ese.	3.6	1674	618.3	5.5	......	wsw.	....
4:33 p. m.....	711.5	2.7	63	ese.	3.6	1308	646.3	6.6	......	sw.	....
4:45 p. m.....	711.3	2.7	62	e.	4.0	1144	659.2	4.3	......	ssw.	....
4:51 p. m.....	711.3	2.6	62	e.	4.0	987	672.0	4.7	......	s.	....
4:56 p. m.....	711.2	2.7	61	e.	4.0	526	711.2	2.7	61	e.	4.0
November 28:											
1:24 p. m.....	704.8	0.8	100	se.	7.6	526	704.8	0.8	100	se.	7.6
1:55 p. m.....	704.6	0.8	100	se.	6.7	704	689.1	−0.3	......	se.	....
1:57 p. m.....	704.6	0.8	100	se.	6.7	744	685.7	0.2	......	se.	....
3:00 p. m.....	704.3	0.8	100	se.	5.8	700	689.1	−1.1	......	se.	....
3:25 p. m.....	704.7	0.8	100	se.	2.2	526	704.7	0.8	100	se.	2.2

November 26.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 7000 m., at maximum altitude.

There were a few to 6/10 St.-Cu. from the north-northwest.

Pressure was high over Michigan and low off the New England coast.

November 27.—One captive balloon was used; capacity 22.4 cu. m. Wire out, 2400 m.

There were 10/10 A.-St. from the southwest.

The pressure was low off the New England coast and over the Mississippi Valley. Pressure was high over the Province of Ontario.

November 28.—Two kites were used; lifting surface, 10.8 sq. m. Wire out, 1000 m.; at maximum altitude, 500 m.

There were dense fog and light rain.

A well-developed low was central over Lake Erie, with a secondary depression over western North Carolina.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
November 29:	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
12:58 p. m	705.9	0.0	89	wnw.	15.2	526	705.9	0.0	89	wnw.	15.2
1:04 p. m	705.9	0.2	88	wnw.	10.7	868	676.3	− 2.6	......	nw.	....
1:15 p. m	705.8	0.3	84	wnw.	16.1	1364	634.9	− 6.3	......	wnw.	....
1:26 p. m	705.7	0.9	71	nw.	16.1	1742	604.7	− 9.1	......	nw.	....
1:41 p. m	705.6	1.0	69	wnw.	16.1	2103	576.9	−10.9	......	nw.	....
2:18 p. m	705.6	0 8	68	wnw.	16 1	2153	573.2	−10 9	......	wnw.	....
2:40 p. m	705 8	0.4	75	wnw.	16.1	2034	582.3	− 5.8	......	wnw.	....
3:11 p. m	705.9	0.0	79	wnw.	16.1	1500	623.8	− 7.6	......	nw.	....
3:24 p. m	706.0	0.0	81	wnw.	14.3	1206	647.7	− 6.3	......	nw.	....
3:38 p. m	706.0	0.2	78	wnw.	16.5	868	676.3	− 3.3	......	wnw.	....
3:43 p. m	706.1	0.0	83	wnw.	16.1	526	706.1	0.0	83	wnw.	16.1
November 30:											
8:31 a. m	705.6	− 3.4	74	wnw.	10.7	526	705.6	− 3.4	74	wnw.	10.7
8:38 a. m	705.6	− 3.4	74	wnw.	8.9	936	669.6	− 6.9	......	wnw.	....
8:48 a. m	705.6	− 3.4	74	wnw.	10.7	1191	648.0	− 9.5	......	wnw.	....
9:02 a. m	705.6	− 3.4	74	wnw.	12.5	1645	611.0	−12.6	......	wnw.	....
9:53 a. m	705.6	− 3.6	77	wnw.	11.2	2054	579.0	−14.5	......	wnw.	....
10:17 a. m	705.3	− 3.2	74	wnw.	10.7	2416	551.7	−14.1	......	n v.	....
11:36 a. m	704.2	− 2.3	69	wnw.	13.0	2235	564.5	−14.9	......	nw.	....
12:00 m	703.8	− 2.2	70	wnw.	15.2	2039	579.0	−12.1	......	wnw.	....
12:11 p. m	703.8	− 2.0	71	wnw.	15.2	1886	590.6	−13.0	......	wnw.	....
12:26 p. m	703.7	− 1.8	73	wnw.	16.1	1508	620.5	−11.1	......	wnw.	....
12:44 p. m	703.7	− 1.8	75	wnw.	15.2	1023	660.6	− 7.5	......	wnw.	....
12:54 p. m	703.6	− 1.8	77	wnw.	16.1	940	667.6	− 5.9	......	wnw.	....
12:58 p. m	703.6	− 1.4	80	wnw.	16.1	526	703.6	− 1.4	80	wnw.	16.1
December 1:											
8:16 a. m	704.3	− 4.4	67	wnw.	13.4	526	704.3	− 4.4	67	wnw.	13.4
8:21 a. m	704.3	− 4.4	67	wnw.	12.1	937	668.2	− 7.8	......	wnw.	....
8:28 a. m	704.3	− 4.6	72	wnw.	13.9	1147	650.3	− 9.3	......	nw.	....
8:35 a. m	704.3	− 4.8	78	wnw.	14.3	1393	630.0	− 7.8	......	nw.	....
9:16 a. m	704.2	− 4.5	74	wnw.	16.1	1816	596.6	− 9.3	......	nnw.	....
10:03 a. m	703.9	− 3.6	73	wnw.	21.9	2728	529.5	−15.2	......	nnw.	....
10:51 a. m	704.1	− 3.6	73	wnw.	19.7	3731	463.4	−19.3	......	nw.	....
11:01 a. m	704.1	− 3.5	73	wnw.	13.4	4180	436.4	−17.5	......	wnw.	....
11:21 a. m	704.2	− 3.3	74	wnw.	16.1	3678	467.1	−19.5	......	nw.	....
11:42 a. m	704.2	− 3.1	71	wnw.	14.3	2778	525.9	−14.9	......	nnw.	....
11:58 a. m	704.3	− 2.8	69	wnw.	13.4	1943	587.6	− 9.0	......	nnw.	....
12:19 p. m	704.3	− 2.2	61	wnw.	12.5	1351	634.0	− 5.8	......	nw.	....
12:31 p. m	704.4	− 2.3	62	wnw.	15.2	1196	646.8	− 6.8	......	nw.	....
12:42 p. m	704.4	− 2.2	63	wnw.	15.6	918	670.2	− 5.8	......	nw.	....
12:46 p. m	704.4	− 2.2	63	wnw.	15.6	526	704.4	− 2.2	63	wnw.	15.6

November 29.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 4500 m.; at maximum altitude, 4100 m.

There were 10/10 St. from the west-northwest at the start, and 2/10 A.-St. and 7/10 St.-Cu. from the northwest at 1:28 p. m. Light snow fell between 12:40 and 1:25 p. m. and 2:39 and 2:55 p. m.

Low pressure was central over Lake Ontario and off Nantucket. Pressure was high over the lower Mississippi and the Northwest.

November 30.—Seven kites were used; lifting surface, 44.6 sq. m. Wire out, 9000 m.; at maximum altitude, 7000 m.

There were from 10/10 to 6/10 St.-Cu. from the west-northwest before 10:04 a. m. and from the northwest thereafter. There were 2/10 A.-Cu. from the northwest after 11:10 a. m.

Pressure was low off the Maine coast and high over Montana.

December 1.—Seven kites were used; lifting surface, 44.1 sq. m. Wire out, 9500 m.; at maximum altitude, 8400 m.

The sky was covered with St. and St.-Cu. from the northwest, their altitude increasing from 1200 m. to 2000 m. Snow fell until 10:20 a. m.

At 8 a. m. a well-developed low was central off the New England coast and a ridge of high pressure extended from North Dakota southward to Texas.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind. Dir.	Wind. Velocity.	Height.	Pressure.	Temperature.	Rel. hum.	Wind. Dir.	Wind. Velocity.
1910.											
December 2:	*mm.*	° *C.*	%		*m.p.s.*	*m.*	*mm.*	° *C.*	%		*m.p.s.*
8:26 a. m.	712.7	− 4.2	75	wnw.	19.2	526	712.7	− 4.2	75	wnw.	19.2
8:32 a. m.	712.7	− 4.1	74	wnw.	18.8	927	677.2	− 7.0	......	nw.	....
8:43 a. m.	712.9	− 4.0	68	wnw.	18.8	1261	648.2	− 8.3	......	nw.	....
8:56 a. m.	713.0	− 3.8	64	wnw.	16.1	1640	618.0	−11.0	......	nnw.	....
9:18 a. m.	712.8	− 3.5	68	wnw.	11.6	2135	579.3	−10.2	......	wnw.	....
9:31 a. m.	712.6	− 3.0	62	wnw.	11.6	2088	582.9	− 8.4	......	nw.	....
9:47 a. m.	712.4	− 3.1	63	wnw.	16.1	2708	538.2	−10.8	......	nw.	....
10:35 a. m.	712.9	− 3.3	77	wnw.	21.5	2043	586.5	− 6.8	......	nw.	....
11:14 a. m.	713.2	− 2.9	78	wnw.	13.4	2165	577.4	−10.5	......	nw.	....
11:32 a. m.	713.0	− 2.6	81	wnw.	14.3	1685	614.4	−11.0	......	nw.	....
11:38 a. m.	712.9	− 2.5	81	nw.	12.5	1384	638.8	−10.0	......	nw.	....
11:50 a. m.	712.7	− 2.4	83	wnw.	12.5	887	680.7	− 6.8	......	wnw.	....
11:56 a. m.	712.6	− 2.1	85	wnw.	13.0	526	712.6	− 2.1	85	wnw.	13.0
December 3:											
8:32 a. m.	718.0	− 5.4	75	wnw.	16.1	526	718.0	− 5.4	75	wnw.	16.1
8:39 a. m.	718.1	− 5.3	72	nw.	15.6	833	690.5	− 7.4	......	nw.	....
8:57 a. m.	718.2	− 4.9	71	nw.	16.1	1251	654.4	− 7.9	......	nw.	....
9:18 a. m.	718.3	− 4.8	71	wnw.	16.1	1430	639.7	− 6.9	......	nw.	....
9:57 a. m.	718.6	− 4.3	71	wnw.	16.1	1849	606.2	−12.2	......	nw.	....
10:42 a. m.	718.6	− 3.5	60	wnw.	10.7	1238	656.1	− 5.6	......	wnw.	....
10:52 a. m.	718.6	− 3.5	59	wnw.	12.1	1108	667.1	− 8.3	......	nw.	....
10:57 a. m.	718.6	− 3.2	59	wnw.	12.5	821	692.2	− 6.1	......	nw.	....
11:02 a. m.	718.6	− 3.0	57	wnw.	13.4	526	718.6	− 3.0	57	wnw.	13.4
December 4:											
4:54 p. m.	715.4	−2.0	90	w.	2.2	526	715.4	−2.0	90	w.	2.2
5:01 p. m.	715.4	−2.0	90	w.	2.7	1138	662.2	−5.4	......	wnw.	....
5:08 p. m.	715.4	−2.0	90	w.	2.7	780	693.0	−3.0	......	wnw.	....
5:22 p. m.	715.5	−2.1	92	w.	2.2	526	715.5	−2.1	92	w.	2.2
December 5:											
1:30 p. m.	712.2	−4.2	100	ese.	10.7	526	712.2	−4.2	100	ese.	10.7
1:45 p. m.	712.1	−4.2	100	ese.	10.3	814	686.5	−6.1	......	ese.	....
1:59 p. m.	712.0	−4.2	100	ese.	9.8	1236	650.3	−6.2	......	ese.	....
2:12 p. m.	711.9	−4.2	100	ese.	10.7	1770	607.5	−4.3	......	s.	....
2:20 p. m.	711.8	−4.2	100	ese.	8.5	1969	592.3	−5.3	......	s.	....
2:27 p. m.	711.8	−4.2	100	ese.	8.9	2340	565.0	−3.7	......	ssw.	....
2:43 p. m.	711.6	−4.2	100	ese.	8.5	2638	544.0	−4.3	......	ssw.	....
3:06 p. m.	711.5	−4.2	100	ese.	8.0	2266	570.4	−2.9	......	ssw.	....
3:15 p. m.	711.5	−4.4	100	ese.	8.0	1896	597.7	−4.7	......	s.	....
3:25 p. m.	711.5	−4.4	100	ese.	8.0	1652	616.5	−3.9	......	se.	....
3:31 p. m.	711.5	−4.4	100	ese.	8.0	1257	648.1	−5.8	......	se.	....
3:42 p. m.	711.5	−4.4	100	ese.	7.2	830	684.5	−5.8	......	ese.	....
3:49 p. m.	711.5	−4.4	100	ese.	7.6	526	711.5	−4.4	100	ese.	7.6

December 2.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 5000 m., at maximum altitude.

3/10 to 4/10 St.-Cu. from the north-northwest prevailed. There was light haze.

A low area was central on the coast of New Brunswick. Pressure was high over the Mississippi Valley.

December 3.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 6000 m., at maximum altitude.

There were a few St.-Cu. from the northwest.

Pressure was low over New Brunswick and high over Tennessee.

December 4.—One captive balloon was used; capacity, 22.4 cu. m. Wire out, 1500 m.

There were 10/10 St.-Cu. from the west-northwest.

Pressure was high over the upper lakes and Florida, and was low over the Gulf of St. Lawrence and the Ohio Valley.

December 5.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 4500 m., at maximum altitude.

There was snow accompanied by dense fog.

Pressure was low over Mississippi and high over Montana.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
December 6:	*mm.*	° *C.*	%		*m.p.s.*	*m.*	*mm.*	° *C.*	%		*m.p.s.*
9:23 a. m.	706.5	−6.6	100	nw.	6.3	526	706.5	−6.6	100	nw.	6.3
9:38 a. m.	706.5	−6.4	100	nw.	6.3	988	666.0	−5.9	......	ne.	....
9:48 a. m.	706.5	−6.2	100	nw.	6.7	1359	635.3	−3.9	......	ne.	....
9:56 a. m.	706.5	−6.2	100	nw.	6.3	1385	633.1	−2.4	......	ne.	....
10:20 a. m.	706.5	−6.3	100	nw.	6.3	1226	646.0	−5.6	......	ene.	....
10:35 a. m.	706.5	−6.2	100	nw.	6.3	1137	653.4	−5.6	......	nne.	....
10:47 a. m.	706.5	−6.2	100	nw.	6.3	526	706.5	−6.2	100	nw.	6.3
December 7:											
9:58 a. m.	712.9	−6.4	100	nw.	12.5	526	712.9	−6.4	100	nw.	12.5
10:03 a. m.	712.9	−6.2	100	wnw.	12.5	816	686.9	−7.8	......	wnw.	....
10:38 a. m.	712.9	−5.4	93	nw.	13.0	1288	647.1	0.0	......	wnw.	....
11:17 a. m.	712.8	−4.6	84	nw.	11.6	1521	628.4	−2.9	......	wnw.	....
12:00 m.	712.4	−4.0	82	wnw.	6.7	1884	599.8	−6.2	......	w.	....
12:07 p. m.	712.4	−3.8	81	wnw.	8.0	2604	546.8	−9.6	......	w.	....
12:17 p. m.	712.3	−3.6	82	wnw.	8.0	2065	587.2	−5.3	......	w.	....
12:27 p. m.	712.3	−3.7	80	wnw.	8.0	1808	605.9	−5.4	......	w.	....
12:33 p. m.	712.2	−3.8	80	wnw.	8.5	1207	653.0	−3.5	......	w.	....
12:42 p. m.	712.2	−3.7	79	wnw.	8.0	970	673.0	−6.9	......	w.	....
12:50 p. m.	712.1	−3.6	77	wnw.	8.5	526	712.1	−3.6	77	wnw.	8.5
December 8:											
8:35 a. m.	717.6	−4.7	76	wsw.	5.8	526	717.6	− 4.7	76	wsw.	5.8
8:52 a. m.	717.8	−4.3	76	wsw.	5.8	875	686.6	− 6.2	......	wsw.	....
9:12 a. m.	717.8	−4.0	74	wsw.	5.8	1523	631.6	−11.1	......	w.	....
9:23 a. m.	717.8	−3.7	72	wsw.	6.7	1868	604.0	− 7.1	......	wnw.	....
9:40 a. m.	717.8	−3.6	66	wsw.	5.4	2414	563.3	− 7.5	......	w.	....
10:02 a. m.	717.8	−3.5	65	wsw.	5.8	3131	513.7	− 9.3	......	w.	....
10:38 a. m.	717.8	−3.4	66	wsw.	7.2	2416	563.3	− 7.2	......	w.	....
10:58 a. m.	717.8	−3.0	64	wsw.	6.7	1871	604.0	− 7.1	......	wnw.	....
11:15 a. m.	717.7	−2.6	62	wsw.	7.6	1526	631.6	− 9.7	......	w.	....
11:31 a. m.	717.5	−2.6	62	wsw.	7.2	874	686.6	− 5.4	......	wsw.	....
11:36 a. m.	717.5	−2.6	62	wsw.	7.2	526	717.5	− 2.6	62	wsw.	7.2

December 6.—Four kites were used; lifting surface, 25.2 sq. m. Wire out 4000 m.; at maximum altitude, 2000 m.

Heavy snow from the east-northeast prevailed throughout the flight.

A low of considerable energy was over the North Carolina coast. Pressure was high over the southern plains region.

December 7.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 5500 m.; at maximum altitude, 2800 m.

There were a few stationary clouds, and, after 11 a. m., 5/10 to 8/10 Ci.-St. and A.-St. from the west-southwest.

At 8 a. m. pressure was high over the Gulf States and low off the New England coast.

December 8.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 6000 m., at maximum altitude.

St.-Cu. from the west-northwest, altitude 1500 m., diminished from 3/10 to none by 10:30 a. m.; after that time there was about 1/10 Ci.-St. from the west.

Pressure was high over the Gulf States, and low north of the lower Lakes.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
December 9:	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
8:40 a. m......	720.7	−9.8	87	nw.	8.9	526	720.7	− 9.8	87	nw.	8.9
8:48 a. m......	720.7	−9.7	86	nw.	8.9	956	681.5	−11.9	......	nw.	....
9:00 a. m......	720.7	−9.7	84	wnw.	9.4	1245	656.1	−12.6	......	wnw.	....
9:11 a. m......	720.7	−9.7	84	wnw.	8.9	1556	630.1	−10.0	......	wnw.	....
9:28 a. m......	720.7	−9.4	78	wnw.	8.9	2150	583.6	− 9.0	......	wnw.	....
9:42 a. m......	720.7	−9.2	81	nw.	8.9	2520	556.3	− 9.5	......	wnw.	....
10:22 a. m......	720.6	−9.0	81	nw.	11.6	3996	458.2	−17.1	......	wnw.	....
11:03 a. m......	720.5	−9.2	79	wnw.	9.8	4405	433.9	−19.4	......	wnw.	....
11:34 a. m......	720.2	−9.2	75	nw.	8.0	3999	458.2	−17.6	......	wnw.	....
12:06 p. m......	719.9	−8.8	74	wnw.	10.3	3247	506.6	−13.9	......	wnw.	....
12:23 p. m......	719.9	−8.4	76	wnw.	10.3	2740	540.7	−10.6	......	wnw.	....
12:34 p. m......	719.9	−8.2	71	wnw.	10.3	2151	583.6	− 8.6	......	nw.	....
12:38 p. m......	719.9	−8.2	71	nw.	9.4	2056	590.8	− 8.5	......	nw.	....
12:57 p. m......	719.9	−7.9	70	nw.	9.4	1074	670.6	− 8.6	......	nw.	....
1:05 p. m......	719.9	−7.7	71	nw.	8.9	911	685.0	−11.2	......	nw.	....
1:16 p. m......	720.0	−7.7	72	nw.	8.9	526	719.9	− 7.7	72	nw.	8.9
December 10:											
8:35 a. m......	720.2	−8.6	88	se.	6.3	526	720.2	− 8.6	88	se.	6.3
8:41 a. m......	720.2	−8.6	88	se.	6.3	829	692.7	− 7.3	......	s.	....
9:12 a. m......	720.2	−8.2	85	se.	6.3	1118	667.6	− 5.6	......	wsw.	....
10:07 a. m......	720.2	−7.0	72	se.	7.2	1318	650.8	− 5.3	......	wsw.	....
10:21 a. m......	720.0	−6.6	68	se.	8.0	2486	560.4	− 8.3	......	wsw.	....
10:34 a. m......	719.8	−6.5	68	se.	8.0	2832	535.7	−10.8	......	w.	....
10:50 a. m......	719.6	−6.4	68	se.	8.0	3864	468.0	−14.0	......	w.	....
11:22 a. m......	719.3	−6.4	68	se.	8.0	4687	419.4	−19.3	......	wnw.	....
12:00 m........	718.8	−7.2	75	se.	8.0	3863	468.0	−14.7	......	w.	....
12:17 p. m......	718.6	−7.0	72	se.	8.5	3030	521.8	−10.5	......	w.	....
12:32 p. m......	718.3	−7.2	78	se.	8.0	2300	573.1	− 8.4	......	w.	....
12:42 p. m......	718.1	−7.4	78	se.	7.6	1960	598.6	− 6.7	......	w.	....
12:54 p. m......	717.8	−7.0	78	se.	8.0	1273	653.0	− 3.5	......	sw.	....
1:00 p. m......	717.8	−6.7	76	se.	8.0	1057	671.1	− 2.6	......	ssw.	....
1:11 p. m......	717.7	−6.8	77	se.	8.5	825	691.0	− 2.7	......	s.	....
1:14 p. m......	717.7	−7.0	78	se.	8.5	526	717.7	− 7.0	78	se.	8.5

December 9.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 9000 m.; at maximum altitude, 8200 m.

There prevailed 5/10 to 6/10 A.-St. from the southwest. A solar halo was observed at 9:09 a. m.

Pressure was low over New Brunswick and high over the eastern half of the country.

December 10.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 7900 m.; at maximum altitude, 7500 m.

St.-Cu. from the west-southwest, altitude 1400 m., diminished from 10/10 to none by 10 a. m. Thereafter the sky was covered with Ci.-St. and A.-St. from the west-northwest, altitude of the A.-St. being 4700 m. A solar halo was observed. After 11:30 a. m. these clouds were obscured by St.-Cu. from the west at an altitude of 2800 m.

At 8 a. m. high pressure overlay the Atlantic seaboard and a low was central northwest of Lake Superior.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
December 11:	*mm.*	*° C.*	%		*m. p. s.*	*m.*	*mm.*	*° C.*	%		*m. p. s.*
8:51 a. m.	713.8	−2.2	85	wnw.	21.5	526	713.8	− 2.2	85	wnw.	21.5
8:57 a. m.	714.0	−1.7	80	wnw.	21.5	929	678.6	− 4.4	......	wnw.	....
9:07 a. m.	714.0	−1.5	80	wnw.	19.7	1164	658.5	− 6.4	......	wnw.	....
9:24 a. m.	714.2	−1.2	74	wnw.	20.6	1642	619.4	−10.9	......	wnw.	....
9:33 a. m.	714.2	−1.2	75	wnw.	19.7	1857	602.5	− 4.6	......	wnw.	....
9:43 a. m.	714.3	−1.2	76	wnw.	13.4	2498	555.1	− 8.5	......	wnw.	....
9:59 a. m.	714.4	−1.1	77	wnw.	13.9	3049	516.5	−12.4	......	wnw.	....
10:14 a. m.	714.4	−1.2	78	wnw.	13.9	2432	558.8	− 8.4	......	wnw.	....
10:17 a. m.	714.4	−1.2	78	wnw.	14.8	2161	578.8	−13.0	......	wnw.	....
10:33 a. m.	714.3	−1.3	81	wnw.	14.8	1618	621.2	−10.2	......	wnw.	....
11:14 a. m.	714.3	−1.4	84	wnw.	16.1	1145	660.3	− 6.9	......	wnw.	....
11:24 a. m.	714.2	−1.3	76	wnw.	17.9	849	685.7	− 4.8	......	wnw.	....
11:29 a. m.	714.2	−1.3	78	wnw.	17.9	526	714.2	− 1.3	78	wnw.	17.9
December 12:											
8:34 a. m.	719.0	−5.1	73	wnw.	6.3	526	719.0	− 5.1	73	wnw.	6.3
8:43 a. m.	719.0	−5.4	86	wnw.	8.9	881	687.0	− 8.2	......	nw.	....
9:07 a. m.	719.1	−5.2	85	wnw.	10.7	1258	654.4	−10.5	......	nw.	....
9:27 a. m.	719.2	−5.2	86	wnw.	9.8	1594	626.6	−11.1	......	nnw.	....
9:32 a. m.	719.2	−5.0	86	wnw.	8.9	1802	609.8	−12.5	......	nnw.	....
9:47 a. m.	719.3	−4.5	77	wnw.	10.7	1417	641.4	− 9.1	......	nnw.	....
10:08 a. m.	719.3	−4.8	84	wnw.	10.7	1531	632.0	− 9.7	......	nnw.	....
10:38 a. m.	719.4	−4.5	80	wnw.	10.7	1954	598.2	−12.8	......	nnw.	....
10:47 a. m.	719.4	−4.4	82	wnw.	10.7	2238	576.4	−12.5	......	nw.	....
10:52 a. m.	719.5	−4.3	83	wnw.	10.7	2743	539.0	−15.2	......	nw.	....
11:02 a. m.	719.5	−4.2	77	wnw.	10.3	2330	569.1	−12.4	......	nw.	....
11:12 a. m.	719.4	−4.3	80	wnw.	10.7	2233	576.4	−15.5	......	nw.	....
11:24 a. m.	719.3	−4.7	85	wnw.	10.7	1950	598.2	−14.4	......	nw.	....
11:33 a. m.	719.3	−4.5	83	wnw.	10.7	1459	637.9	−10.3	......	nw.	....
11:45 a. m.	719.2	−4.7	86	wnw.	12.1	927	683.3	− 8.0	......	nw.	....
11:51 a. m.	719.1	−4.2	82	nw.	12.1	526	719.1	− 4.2	82	nw.	12.1
December 13:											
8:36 a. m.	725.8	−9.6	80	nw.	17.9	526	725.8	− 9.6	80	nw.	17.9
8:43 a. m.	726.0	−9.5	80	nw.	17.9	914	690.3	−10.4	......	nnw.	....
9:00 a. m.	726.2	−9.5	80	nw.	14.3	1163	668.7	− 5.0	......	nnw.	....
9:54 a. m.	726.4	−8.6	77	nw.	17.0	1826	614.9	− 7.2	......	n.	....
10:07 a. m.	726.4	−8.6	80	nw.	16.1	2427	568.8	−11.8	......	n.	....
10:41 a. m.	726.0	−8.2	71	nw.	17.9	2943	531.3	−15.2	......	n.	....
11:16 a. m.	725.8	−7.5	72	nw.	17.9	3658	483.5	−16.8	......	n.	....
11:53 a. m.	725.6	−7.0	72	nw.	20.6	2818	540.5	−12.9	......	nnw.	....
12:12 p. m.	725.5	−6.6	71	nw.	20.6	1752	620.3	− 5.7	......	nnw.	....
12:22 p. m.	725.4	−6.4	70	wnw.	19.7	1140	670.4	− 3.3	......	nw.	....
12:37 p. m.	725.4	−6.1	74	wnw.	20.6	911	690.3	− 9.1	......	nw.	....
12:49 p. m.	725.3	−6.0	74	wnw.	19.7	526	725.3	− 6.0	74	wnw.	19.7

December 11.—Three kites were used; lifting surface, 18.9 sq. m. Wire out, 6000 m.; at maximum altitude, 5800 m.

There were 10/10 St.-Cu. from the west-northwest at an altitude of 1500 to 1600 m. Light snow fell after 11:15 a. m.

Pressure was low over the Lake region and high over North Dakota and the St. Lawrence Valley.

December 12.—Six kites were used; lifting surface 37.8 sq. m. Wire out, 5500 m.; at maximum altitude, 3200 m.

There were 10/10 to 3/10 St.-Cu. from the northwest. Light snow between 8:25 a. m. and 8:45 a. m. Head kite in St.-Cu. clouds at 10:28 a. m.

Pressure was comparatively low over the lower Lakes and off the New England coast. An extensive high area was central over northern Minnesota.

December 13.—Six kites were used; lifting surface, 37.8 sq. m. Wire out, 7000 m.; at maximum altitude, 5800 m.

The sky was cloudless.

An extensive high, central over Illinois, covered the entire country.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
December 14:	*mm.*	° *C.*	%		*m.p.s.*	*m.*	*mm.*	° *C.*	%		*m.p.s.*
8:51 a.m.	721.6	−3.8	64	w.	15.2	526	721.6	−3.8	64	w.	15.2
8:58 a.m.	721.6	−3.8	55	w	13.4	849	692.7	−3.2	......	wnw.	....
9:05 a.m.	721.6	−3.6	60	w.	13.4	1015	678.5	−0.5	......	nw.	....
9:17 a.m.	721.6	−3.4	80	w.	15.2	1478	640.2	−2.3	......	wnw.	....
9:28 a.m.	721.6	−3.2	48	wsw.	14.3	1838	612.1	1.9	......	wnw.	....
9:48 a.m.	721.5	−2.8	68	w.	16.1	2541	560.5	−3.0	......	wnw.	....
10:13 a.m.	721.4	−2.3	85	w.	16.1	3242	512.7	−7.3	......	wnw.	....
10:37 a.m.	721.1	−1.5	82	w.	16.1	3772	478.8	−9.8	......	wnw.	....
11:12 a.m.	720.5	−1.2	65	w.	15.2	2790	543.2	−3.8	......	wnw.	....
11:45 a.m.	720.0	−0.8	33	w.	13.4	1566	632.5	3.5	......	wnw.	....
11:55 a.m.	719.9	−0.5	37	w.	13.4	1328	651.3	0.8	......	wnw.	....
12:07 p.m.	719.8	−0.4	45	w.	13.4	1086	671.2	1.8	......	wnw.	....
12:12 p.m.	719.8	−0.6	47	w.	14.3	894	687.5	−0.1	......	wnw.	....
12:17 p.m.	719.8	−0.8	52	w.	13.4	526	719.8	−0.8	52	w.	13.4
December 15:											
8:24 a.m.	709.6	0.8	52	wsw.	13.9	526	709.6	0.8	52	wsw.	13.9
8:31 a.m.	709.5	0.6	50	wsw.	13.4	940	674.0	2.1	......	w.	....
8:40 a.m.	709.4	1.2	44	wsw.	13.0	1361	639.6	−0.3	......	wnw.	....
9:14 a.m.	709.0	3.1	50	wsw.	10.3	1456	632.0	1.1	......	w.	....
9:28 a.m.	708.4	4.0	43	wsw.	10.3	1765	607.6	−1.1	......	w.	....
10:00 a.m.	708.0	4.4	44	wsw.	10.7	1492	628.4	2.3	......	w.	....
10:33 a.m.	707.4	4.3	39	wsw.	10.3	1415	633.8	1.3	......	w.	....
10:58 a.m.	706.8	4.4	40	wsw.	10.7	1021	665.0	2.7	......	wsw.	....
11:10 a.m.	706.6	4.8	36	wsw.	13.4	826	681.0	3.6	......	wsw.	....
11:16 a.m.	706.4	5.0	43	wsw.	13.4	526	706.4	5.0	43	wsw.	13.4
December 16:											
8:20 a.m.	720.1	−11.7	77	wnw.	8.5	526	720.1	−11.7	77	wnw.	8.5
8:28 a.m.	720.2	−11.4	78	wnw.	9.4	891	686.6	−14.0	......	nw.	....
8:40 a.m.	720.4	−11.4	78	wnw.	9.8	1456	637.2	−18.0	......	nw.	....
8:52 a.m.	720.6	−11.4	80	wnw.	8.9	1768	611.4	−16.0	......	nw.	....
9:07 a.m.	720.8	−11.5	80	wnw.	8.9	2362	565.3	−14.4	......	nw.	....
9:23 a.m.	720.9	−11.3	78	wnw.	7.6	3168	508.3	−16.6	......	nw.	....
9:30 a.m.	721.0	−11.2	78	wnw.	7.2	3356	496.0	−14.5	......	nw.	....
10:08 a.m.	721.1	−10.2	74	wnw.	6.7	3097	513.8	−16.5	......	nw.	....
10:25 a.m.	721.1	−10.1	74	wnw.	8.5	2228	576.2	−12.9	......	nw.	....
10:38 a.m.	721.1	−9.7	74	wnw.	9.4	1801	609.6	−14.8	......	nnw.	....
10:50 a.m.	721.1	−9.7	74	wnw.	10.7	1335	648.4	−16.4	......	nnw.	....
11:03 a.m.	721.1	−9.6	74	wnw.	9.8	922	684.9	−13.2	......	nw.	....
11:12 a.m.	721.0	−9.5	74	wnw.	8.5	526	721.0	−9.5	74	wnw.	8.5

December 14.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 8000 m.; at maximum altitude, 7500 m.

There were 6/10 to 7/10 A.-St. from the north-northwest during the flight. A solar halo was observed from 10:18 to 10:45 a. m.

Pressure was low north of the Great Lakes and high over the South Atlantic and east Gulf States.

December 15.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 5500 m., at maximum altitude.

There were a few to 2/10 St.-Cu. from the west.

Pressure was low over Maine and high over Wyoming.

December 16.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 6500 m.; at maximum altitude, 5500 m.

Ci.-St., from the west-northwest, and A.-St., from the north-northwest, diminished from 4/10 each to 1/10 each. There was a solar halo.

At 8 a. m. pressure was high from the Lake region to the Gulf of Mexico and low over the Gulf of St. Lawrence.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
December 17:	*mm.*	° *C.*	%		*m.p.s.*	*m.*	*mm.*	° *C.*	%		*m.p.s.*
12:39 p. m.....	722.6	−1.2	69	se.	3.6	526	722.6	−1.2	69	se.	3.6
12:52 p. m.....	722.6	−1.4	68	se.	4.5	1380	649.1	−1.3	......	wnw.	....
1:22 p. m.....	722.6	−1.8	49	se.	4.9	901	689.3	−1.4	......	sw.	....
1:26 p. m.....	722.6	−1.8	49	se.	5.4	760	701.7	−2.4	......	ssw.	....
1:40 p. m.....	722.6	−3.8	59	se.	5.4	526	722.6	−3.8	59	se.	5.4
December 18:											
11:52 a. m......	716.6	−2.7	82	sse.	4.0	526	716.6	−2.7	82	sse.	4.
11:56 a. m......	716.6	−3.1	82	sse.	4.0	860	687.5	4.5	......	sw.	....
12:06 p. m......	716.4	−3.8	89	sse.	5.4	1187	660.2	4.5	......	sw.	....
12:15 p. m......	716.2	−3.7	82	sse.	6.7	1752	615.7	2.0	......	sw.	....
12:34 p. m......	715.8	−2.3	80	sse.	6.7	2196	582.4	−0.7	......	sw.	....
12:57 p. m......	715.2	−3.8	84	sse.	8.9	3113	518.3	−5.0	......	sw.	....
1:30 p. m......	715.0	−4.7	92	sse.	6.3	2519	558.7	−2.3	......	sw.	....
1:45 p. m......	714.9	−4.4	86	sse.	6.3	1763	613.9	2.0	......	ssw.	....
1:58 p. m......	714.8	−4.7	79	sse.	6.7	1082	667.6	3.6	......	ssw.	....
2:07 p. m......	714.7	−4.6	80	sse.	8.0	676	701.6	5.5	......	ssw.	....
2:10 p. m......	714.7	−4.6	81	sse.	8.0	526	714.7	−4.6	81	sse.	8.0
December 19:											
First flight—											
8:47 a. m....	705.8	−0.5	86	nw.	5.8	526	705.8	− 0.5	86	nw.	5.8
9:03 a. m....	705.8	−0.4	82	wnw.	5.4	888	674.4	− 3.9	......	wnw.	....
9:15 a. m....	705.8	−0.4	84	nw.	5.4	1276	641.8	− 7.7	......	wnw.	....
9:23 a. m....	705.7	−0.4	85	nw.	4.5	1388	632.5	− 8.5	......	wnw.	....
10:03 a. m....	705.6	−0.3	85	wnw.	8.0	1204	647.5	− 7.4	......	wnw.	....
10:20 a. m....	705.5	−0.3	85	wnw.	5.4	1181	649.3	− 7.4	......	wnw.	....
10:31 a. m....	705.5	−0.5	86	wnw.	5.4	526	705.5	− 0.5	86	wnw.	5.4
Second flight—											
3:49 p. m...	703.5	−0.4	77	wnw.	6.3	526	703.5	− 0.4	77	wnw.	6.3
4:10 p. m...	703.5	−0.6	82	nw.	5.4	1007	662.8	− 4.5	......	wsw.	....
4:26 p. m...	703.4	−0.8	84	wnw.	3.6	2046	579.5	−10.0	......	w.	....
4:30 p. m...	703.4	−0.8	84	wnw.	4.5	2241	565.0	− 9.5	......	w.	....
4:52 p. m...	703.2	−1.0	86	wnw.	4.5	2568	541.3	−11.0	......	w.	....
5:03 p. m...	703.2	−1.0	90	wnw.	4.5	2289	561.3	− 9.0	......	w.	....
5:18 p. m...	703.2	−1.2	88	wnw.	5.4	1649	609.7	− 9.0	......	wsw.	....
5:32 p. m...	703.2	−1.3	87	wnw.	4.5	1037	659.3	− 4.4	......	w.	....
5:40 p. m...	703.1	−1.2	88	wnw.	4.5	526	703.1	− 1.2	88	wnw.	4.5

December 17.—One captive balloon was used; capacity, 22.4 cu. m. Wire out, 2200 m.
There were a few Ci. from the southwest.
Pressure was high over Virginia and low over Iowa.

December 18.—Four kites were used; lifting surface, 27.2 sq. m. Wire out, 4500 m., at maximum altitude.
There were 9/10 to 4/10 A.-St. from the southwest at an elevation of about 3100 m.
The pressure was low over the upper Lake region and high off the Middle Atlantic coast and over the Rocky Mountains.

December 19.—First flight: Three kites were used; lifting surface, 18.9 sq. m. Wire out, 1650 m.; at maximum altitude, 1400 m.
Second flight: Three kites were used; lifting surface, 20.9 sq. m. Wire out, 4000 m.; at maximum altitude, 3800 m.
During the first flight there were 7/10 St.-Cu. from the northwest.
During the second, there were 7/10 to 6/10 A.-St. from the west-northwest, at about 1700 m. altitude.
A low-pressure area was central over the Province of Ontario. Pressure was also low off the Middle Atlantic coast. Pressure was high over the Rocky Mountain region.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
December 20:	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
10:34 a. m.	700.6	−5.2	86	nw.	11.6	526	700.6	−5.2	86	nw.	11.6
10:45 a. m.	700.6	−5.2	84	nw.	14.8	932	665.1	−8.8	......	nw.	....
10:59 a. m.	700.6	−4.8	81	nw.	14.3	1367	628.6	−11.3	......	nw.	....
11:20 a. m.	700.6	−4.6	78	nw.	14.3	2053	574.6	−15.4	......	wnw.	....
11:38 a. m.	700.6	−4.0	68	wnw.	14.3	2441	545.5	−18.2	......	wnw.	....
11:41 a. m.	700.6	−3.9	68	wnw.	14.3	2542	538.2	−16.5	......	wnw.	....
11:56 a. m.	700.6	−3.9	65	wnw.	12.1	2732	524.5	−19.0	......	wnw.	....
12:18 p. m.	700.5	−4.1	68	wnw.	9.4	2510	540.0	−15.4	......	wnw.	....
12:36 p. m.	700.5	−4.4	66	wnw.	10.3	2283	556.4	−18.7	......	wnw.	....
12:56 p. m.	700.4	−4.6	58	wnw.	14.8	1916	584.3	−16.4	......	wnw.	....
1:30 p. m.	700.4	−4.9	68	wnw.	13.4	1362	628.6	−13.0	......	wnw.	....
1:38 p. m.	700.4	−4.9	68	wnw.	13.4	909	666.8	−9.3	......	nw.	....
1:44 p. m.	700.4	−5.0	66	wnw.	15.2	526	700.4	−5.0	66	wnw.	15.2
December 21:											
3:22 p. m.	712.9	−8.2	65	nw.	19.7	526	712.9	−8.2	65	nw.	19.7
3:30 p. m.	713.1	−8.2	65	wnw.	19.7	855	683.3	−11.7	......	nw.	....
3:49 p. m.	713.4	−8.4	61	nw.	14.3	1293	645.4	−13.6	......	nnw.	....
4.09 p. m.	713.7	−8.5	66	nw.	18.8	1559	623.6	−11.1	......	nnw.	....
4:24 p. m.	713.8	−8.8	62	wnw.	17.9	1318	643.6	−15.1	......	nnw.	....
4:33 p. m.	713.8	−8.8	62	nw.	20.6	1004	670.7	−18.0	......	nw.	....
4:50 p. m.	713.9	−9.0	70	nw.	17.0	526	713.9	−9.0	70	nw.	17.0
December 22:											
10:14 a. m.	724.1	−8.2	77	nw.	6.7	526	724.1	−8.2	77	nw.	6.7
10:15 a. m.	724.1	−8.2	75	nw.	7.2	656	712.0	−8.7	......	nw.	....
10:34 a. m.	724.1	−8.0	71	nw.	10.3	1062	676.2	−1.2	......	nnw.	....
10:57 a. m.	724.1	−7.4	66	nw.	10.7	897	690.8	1.2	......	n.	....
11:10 a. m.	724.1	−7.1	67	wnw.	8.9	855	694.3	−2.3	......	nnw.	....
11:24 a. m.	724.1	−6.9	70	wnw.	3.6	1301	656.4	−1.8	......	nnw.	....
11:30 a. m.	724.1	−6.8	72	wnw.	3.6	526	724.1	−6.8	72	wnw.	3.6
December 23:											
8:55 a. m.	721.1	−5.0	71	s.	8.9	526	721.1	−5.0	71	s.	8.9
9:00 a. m.	721.1	−5.0	71	s.	9.8	881	689.6	1.1	......	sw.	....
9:08 a. m.	721.1	−5.0	76	s.	8.9	1158	661.2	0.0	......	sw.	....
9:18 a. m.	721.1	−5.0	80	s.	8.0	1548	634.7	2.5	......	ssw.	....
9:29 a. m.	721.1	−5.0	87	s.	9.8	1906	607.1	0.5	......	ssw.	....
9:41 a. m.	721.1	−5.1	89	s.	10.7	1572	632.9	2.0	......	ssw.	....
9:57 a. m.	721.1	−5.2	90	s.	7.6	1007	678.9	2.5	......	ssw.	....
10:08 a. m.	721.1	−5.2	90	s.	10.7	921	686.1	0.5	......	ssw.	....
10:18 a. m.	721.1	−5.0	90	s.	8.9	526	721.1	−5.0	90	s.	8.9

December 20.—Five kites were used; lifting surface, 27.0 sq. m. Wire out, 6100 m.; at maximum altitude, 5500 m.

There were 7/10 to 10/10 St.-Cu. from the west-northwest. The head kite was in the clouds at intervals from 12:03 to 1:08 p. m.

Pressure was low over Lake Ontario and high over Montana.

December 21.—Two kites were used; lifting surface, 10.8 sq. m. Wire out, 3300 m.; at maximum altitude, 2800 m.

There were a few St.-Cu. from the northwest.

A well-developed low was off the New England coast. High pressure was central over the lower Mississippi Valley.

December 22.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 2500 m.; at maximum altitude, 2300 m.

There was 1/10 Ci. probably from the southwest.

High pressure covered the country east of the Mississippi. Pressure was low over the plains region.

December 23.—Two kites were used; lifting surface, 12.6 sq. m. Wire out, 2400 m.; at maximum altitude, 2200 m.

There were 10/10 St. from the southwest. Light rain fell after 9:03 a. m.

Pressure was low over Lake Superior and high off the Middle Atlantic coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910. December 24:	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
10:47 a. m.	711.5	−0.8	89	nw.	18.8	526	711.5	−0.8	89	nw.	18.8
11:06 a. m.	711.4	−1.1	80	wnw.	17.9	930	676.0	−5.1	......	nw.	....
11:17 a. m.	711.3	−1.4	80	wnw.	17.9	1119	660.0	2.3	......	nw.	....
11:39 a. m.	711.1	−1.8	75	wnw.	20.6	1530	627.0	0.9	......	nw.	....
11:56 a. m.	710.9	−2.2	75	wnw.	25.0	1742	610.4	−2.5	......	wnw.	....
12:03 p. m.	710.9	−2.3	75	wnw.	22.4	1364	639.9	2.3	......	wnw.	....
12:33 p. m.	710.8	−2.8	74	nw.	22.4	1158	656.2	3.6	......	nw.	....
12:57 p. m.	710.7	−3.0	69	nw.	22.4	836	683.2	−6.3	......	nw.	....
1:10 p. m.	710.6	−3.0	68	nw.	23.2	526	710.6	−3.0	68	nw.	23.2
December 25:											
9:07 a. m.	719.6	−5.2	66	nw.	16.5	526	719.6	− 5.2	66	nw.	16.5
9:18 a. m.	719.6	−5.1	76	nw.	15.6	992	677.8	−10.0	......	wnw.	....
9:50 a. m.	719.7	−5.0	71	wnw.	19.7	1361	646.6	− 1.5	......	nw.	....
11:00 a. m.	719.9	−5.0	76	wnw.	22.4	1081	670.5	1.1	......	nw.	....
11:23 a. m.	720.0	−5.0	76	wnw.	14.3	1018	676.0	− 9.5	......	wnw.	....
11:33 a. m.	720.0	−4.8	66	wnw.	15.6	526	720.0	− 4.8	66	wnw.	15.6
December 26:											
8:38 a. m.	717.9	−6.4	92	se.	4.5	526	717.9	− 6.4	92	se.	4.5
8:43 a. m.	717.9	−6.4	92	se.	3.6	685	703.6	− 1.6	......	sw.	....
9:03 a. m.	717.9	−5.8	89	sse.	4.9	1018	674.9	− 0.7	......	wsw.	....
9:18 a. m.	717.9	−5.4	86	s.	5.8	1579	629.1	− 1.6	......	w.	....
9:50 a. m.	717.9	−4.6	88	sse.	5.8	2311	573.4	− 6.5	......	wsw.	....
10:03 a. m.	717.9	−4.7	83	sse.	4.5	2838	536.0	− 7.9	......	sw.	....
10:21 a. m.	717.7	−5.0	88	se.	3.6	3236	509.2	−10.5	......	sw.	....
10:54 a. m.	717.4	−5.0	86	se.	4.0	2406	566.2	− 5.1	......	sw.	....
11:19 a. m.	717.0	−5.1	88	se.	3.6	1500	634.5	− 1.1	......	wsw.	....
11:23 a. m.	717.0	−4.9	86	se.	4.0	1316	649.3	− 2.0	......	wsw.	....
11:37 a. m.	716.9	−3.4	74	s.	4.0	617	708.8	0.6	......	sw.	....
11:39 a. m.	716.8	−3.5	72	s.	3.1	526	716.8	− 3.5	72	s.	3.1

December 24.—Four kites were used; lifting surface 21.6 sq. m. Wire out, 3880 m., at maximum altitude.

A.-St. and St.-Cu. from the west-southwest covered the sky. A lower layer of St.-Cu. was moving from the northwest at the beginning of the flight.

A low was central off the Virginia coast. Pressure was high over the Mississippi Valley.

December 25.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 3000 m., at maximum altitude.

There were 1/10 to 8/10 St.-Cu. from the northwest.

Pressure was high over Kentucky and north of Lake Huron and low over Nova Scotia.

December 26.—Four kites were used; lifting surface, 25.7 sq. m. Wire out, 5000 m.; at maximum altitude, 4800 m.

The sky was covered with A.-St., from the southwest, at an altitude of about 3000 m. Head kite in A.-St. 10:08 to 10:29 a. m.

High pressure was central off the Virginia coast, low pressure north of Lake Huron.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910. December 27:	*mm.*	° *C.*	%		*m.p.s.*	*m.*	*mm.*	° *C.*	%		*m.p.s.*
7:32 a. m......	719.1	−0.3	......	w.	7.2	526	719.1	−0.3	......	w.	7.2
7:48 a. m......	719.1	−0.6	77	wnw.	7.2	884	687.6	−1.8	......	w.	....
7:57 a. m......	719.1	−0.7	77	wnw.	8.0	1185	662.1	0.0	......	wnw.	....
8:16 a. m......	719.1	−1.2	86	wnw.	7.4	1617	627.2	−1.1	......	nw.	....
8:24 a. m......	719.1	−1.1	86	wnw.	6.3	1717	619.4	−0.3	......	nw.	....
9:22 a. m......	719.3	−0.5	75	wnw.	8.9	1814	612.2	0.9	......	nw.	....
10:03 a. m......	719.4	0.2	72	wnw.	10.3	2626	553.3	−3.0	......	wnw.	....
10:27 a. m......	719.4	0.8	69	wnw.	9.4	1868	608.6	1.7	......	wnw.	....
10:32 a. m......	719.3	0.8	69	wnw.	8.0	1551	632.6	0.1	......	wnw.	....
10:41 a. m......	719.3	1.0	69	wnw.	8.0	1559	632.6	2.8	......	wnw.	....
11:01 a. m......	719.3	1.4	68	wnw.	9.8	848	691.1	−0.3	......	wnw.	....
11:10 a. m......	719.3	1.6	63	wnw.	9.8	526	719.3	−1.6	63	wnw.	9.8
December 28:											
8:16 a. m......	717.3	0.0	80	s.	9.8	526	717.3	0.0	80	s.	9.8
8:23 a. m......	717.3	0.3	78	sse.	8.9	1068	671.0	6.7	......	sw.	....
8:34 a. m......	717.2	0.2	80	s.	9.8	1390	645.3	7.1	......	sw.	....
8:42 a. m......	717.2	0.4	......	s.	10.7	1659	624.5	5.2	......	sw.	....
8:53 a. m......	717.2	1.3	73	s.	9.8	2081	593.0	2.2	......	sw.	....
9:12 a. m......	717.1	1.4	70	ssw.	10.7	2485	563.9	− 0.3	......	sw.	....
9:34 a. m......	717.1	1.8	68	s.	7.6	2843	539.2	− 3.1	......	sw.	....
9:44 a. m......	717.1	1.8	71	s.	6.3	3526	494.7	− 2.6	......	sw.	....
9:50 a. m......	717.1	1.6	72	s.	8.0	3482	498.3	− 1.9	......	sw.	....
10:03 a. m......	717.0	1.4	73	sse.	6.3	3150	519.8	− 4.1	......	sw.	....
10:34 a. m......	716.4	1.2	76	sse.	8.0	2711	548.4	− 1.3	......	wsw.	....
11.03 a. m......	715.9	1.4	77	s.	9.8	2279	578.5	2.5	......	sw.	....
11:25 a. m......	715.5	1.8	72	s.	10.7	1675	622.7	6.3	......	sw.	....
11:40 a. m......	715.2	2.2	71	s.	7.2	1146	663.6	9.4	......	sw.	....
11:54 a. m......	715.0	2.2	68	s.	10.7	853	687.2	10.9	......	sw.	....
11:56 a. m......	715.0	2.2	68	s.	10.7	526	715.0	2.2	68	s.	10.7

December 27.—Six kites were used; lifting surface, 38.3 sq. m. Wire out, 6500 m.; at maximum altitude, 5200 m.

There were no clouds.

Pressure was high over the Middle and South Atlantic States and low over the Province of Ontario and the Rocky Mountain region.

December 28.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 6000 m.; at maximum altitude, 5900 m.

The sky was 9/10 to 10/10 covered with A.-St. from the west-northwest and St.-Cu. from the west-southwest before 9 a. m., and 9/10 to 10/10 with St.-Cu. from the west-southwest and Ci.-St. from the west after 9 a. m. The altitude of the St.-Cu. was about 2800 m.

An area of low pressure was central over Indiana, while a high-pressure area was central off the Atlantic coast.

Results of free air observations.

Date and hour.	On Mount Weather, Va., 526 m.					At different heights above sea.					
	Pressure.	Temperature.	Rel. hum.	Wind.		Height.	Pressure.	Temperature.	Rel. hum.	Wind.	
				Dir.	Velocity.					Dir.	Velocity.
1910.											
December 29:	*mm.*	° *C.*	%		*m. p. s.*	*m.*	*mm.*	° *C.*	%		*m. p. s.*
11:26 a. m.	712.8	11.4	71	s.	8.5	526	712.8	11.4	71	s.	8.5
11:36 a. m.	712.5	11.5	71	s.	7.2	864	684.3	11.1	......	sw.	....
11:48 a. m.	712.2	11.3	71	s.	7.2	1403	641.1	7.7	......	wsw.	....
12:02 p. m.	711.9	12.3	69	ssw.	5.4	1891	603.8	5.3	......	sw.	....
12:23 p. m.	711.5	13.4	65	sw.	4.0	2480	561.4	− 0.5	......	sw.	....
12:39 p. m.	711.2	13.0	68	ssw.	4.0	2995	525.9	− 1.9	......	sw.	....
12:57 p. m.	710.9	10.4	76	ssw.	4.0	3104	518.5	− 0.6	......	sw.	....
1:16 p. m.	710.8	8.9	81	s.	5.4	3615	486.2	− 2.1	......	sw.	....
1:33 p. m.	710.8	8.6	81	s.	5.4	4114	456.5	− 5.2	......	sw.	....
2:11 p. m.	710.7	8.3	85	s.	6.7	3650	484.4	− 2.2	......	sw.	....
2:47 p. m.	710.7	9.0	88	s.	8.5	2909	531.4	2.8	......	sw.	....
3:05 p. m.	710.7	9.0	88	s.	8.0	2540	556.0	4.8	......	sw.	....
3:13 p. m.	710.7	9.2	87	s.	8.0	2331	570.5	1.3	......	sw.	....
3:23 p. m.	710.7	9.5	84	s.	8.0	1920	600.2	3.3	......	sw.	....
3:40 p. m.	710.7	10.0	81	s.	10.3	1427	637.6	6.3	......	sw.	....
3:50 p. m.	710.7	10.4	81	s.	9.4	863	682.6	10.8	......	sw.	....
3:57 p. m.	710.7	10.6	81	s.	10.3	526	710.7	10.6	81	s.	10.3
December 30:											
3:57 p. m.	717.7	−3.2	91	wnw.	21.5	526	717.7	− 3.2	91	wnw.	21.5
4:04 p. m.	717.9	−3.2	84	wnw.	21.5	932	681.8	− 7.0	......	nw.	....
4:12 p. m.	718.0	−3.4	76	wnw.	24.1	1453	637.6	− 9.2	......	nw.	....
4:16 p. m.	718.1	−3.4	78	wnw.	24.1	1587	626.8	− 6.2	......	nw.	....
4:25 p. m.	718.3	−3.6	73	nw.	24.1	2048	591.1	− 6.4	......	nw.	....
4:49 p. m.	718.8	−3.8	76	nw.	23.2	1621	624.4	− 6.3	......	nw.	....
5:01 p. m.	719.0	−3.8	82	nw.	21.5	1504	634.0	−11.1	......	nw.	....
5:22 p. m.	719.4	−3.6	77	nw.	21.5	968	680.0	− 7.6	......	nw.	....
5:31 p. m.	719.4	−3.6	77	nw.	22.4	526	719.4	− 3.6	77	nw.	22.4
December 31:											
2:12 p. m.	728.4	−3.8	72	sse.	8.0	526	728.4	−3.8	72	sse.	8.0
2:26 p. m.	728.4	−3.7	64	se.	10.7	929	691.8	−8.4	......	s.	....
2.47 p. m.	728.4	−3.3	66	sse.	9.8	1608	635.0	1.5	......	ssw.	....
3:18 p. m.	728.4	−3.9	66	sse.	11.6	1942	609.2	2.6	......	ssw.	....
3.51 p. m.	728.4	−4.0	64	sse.	10.7	2396	575.8	−1.4	......	sw.	....
4:13 p. m.	728.4	−4.2	64	se.	10.7	2074	599.4	0.7	......	ssw.	....
4:24 p. m.	728.4	−4.3	68	se.	9.8	1632	633.2	1.3	......	ssw.	....
4:36 p. m.	728.4	−4.5	71	sse.	10.7	871	697.0	−7.4	......	s.	....
4:40 p. m.	728.4	−4.5	72	sse.	9.8	526	728.4	−4.5	72	sse.	9.8

December 29.—Four kites were used; lifting surface, 25.2 sq. m. Wire out, 7500 m., at maximum altitude.

There were 2/10 to 10/10 A.-Cu. from the southwest. From 12:40 to 1:57 p. m. there were 6/10 Ci.-St. from the west, and after 3:25 p. m. 1/10 to 3/10 Ci.-Cu. from the west.

Pressure was low over Tennessee and high off the Atlantic coast.

December 30.—Two kites were used; lifting surface, 10.8 sq. m. Wire out, 3000 m., at maximum altitude.

There were a few to 8/10 St.-Cu. from the northwest.

A low-pressure area of great intensity was central over New Brunswick. Pressure was high over the Mississippi Valley and Texas.

December 31.—Five kites were used; lifting surface, 31.5 sq. m. Wire out, 5500 m.; at maximum altitude, 4400 m.

There were 8/10 Ci.-St. from the west.

Pressure was high over the Atlantic coast and was low over Manitoba and Colorado.

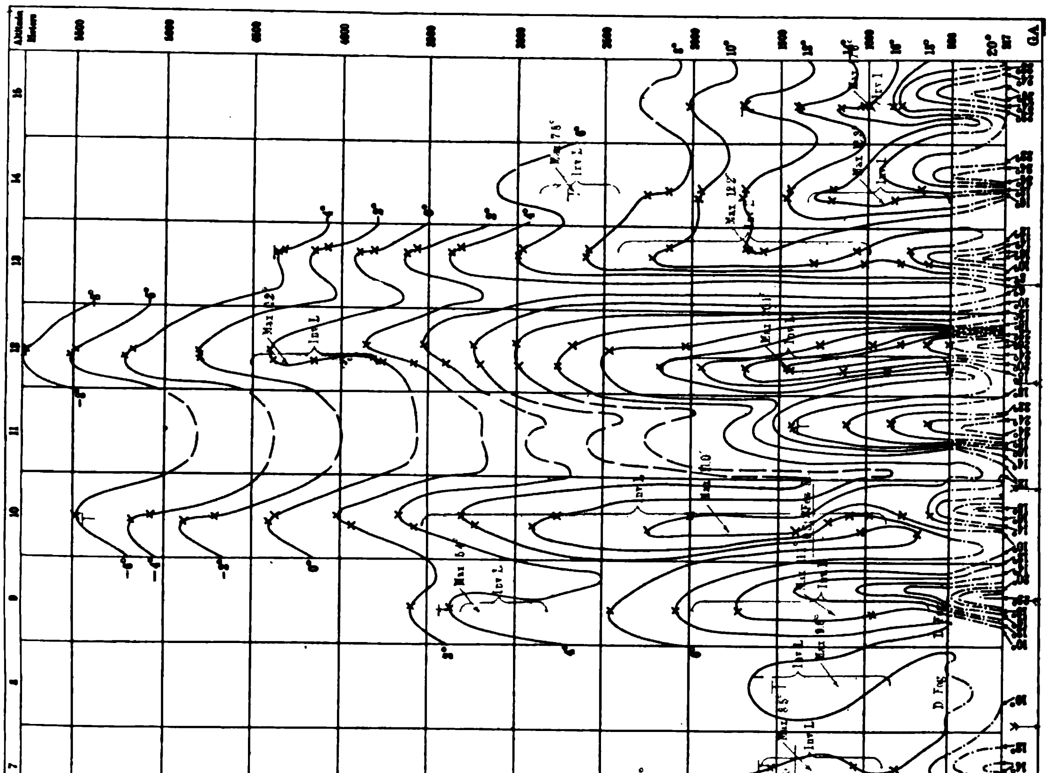


CHART XIX.—Free-air isotherms, October 1–15, 1910.

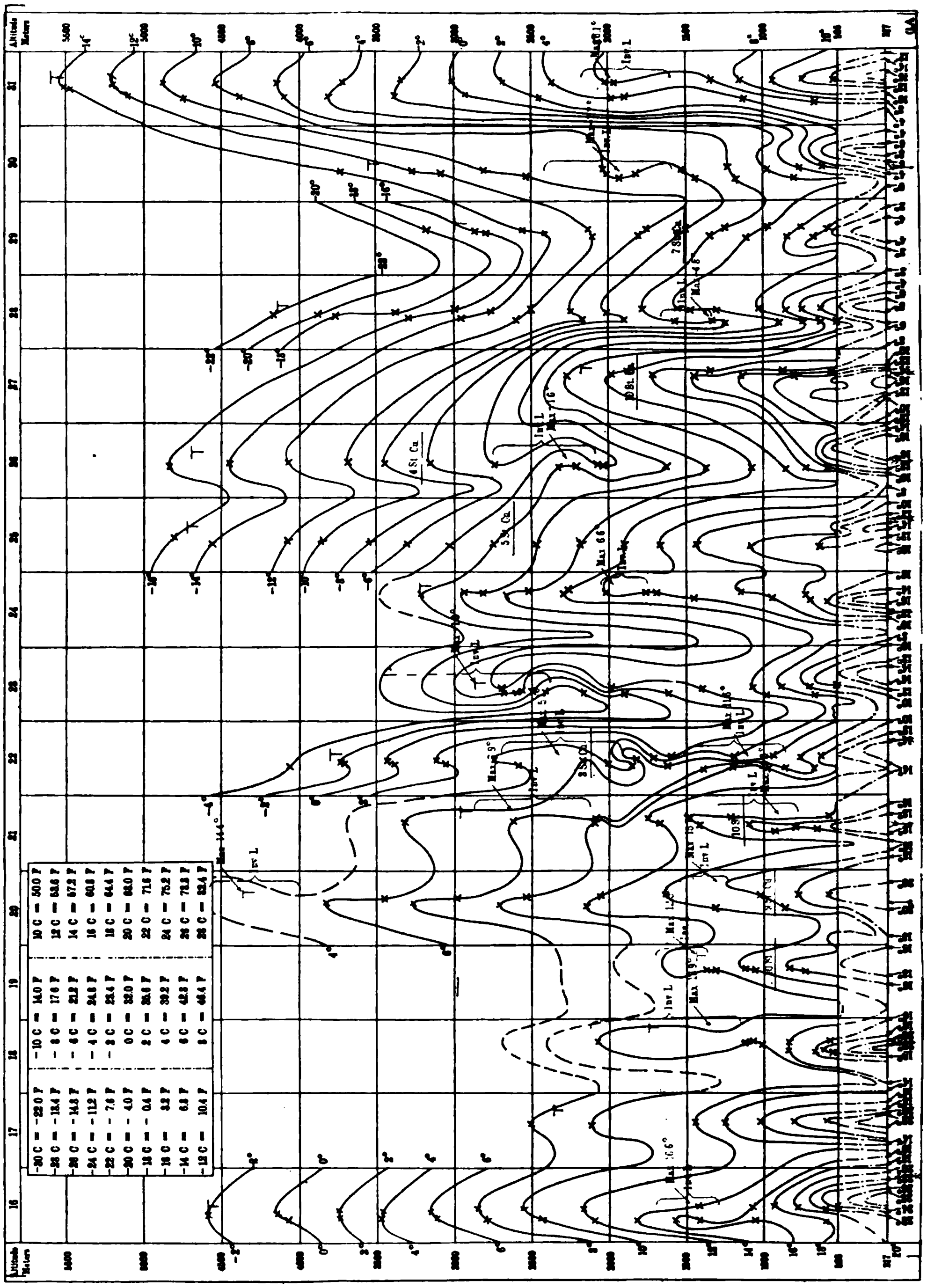


CHART XX.—Free-air isotherms, October 16–31, 1910.

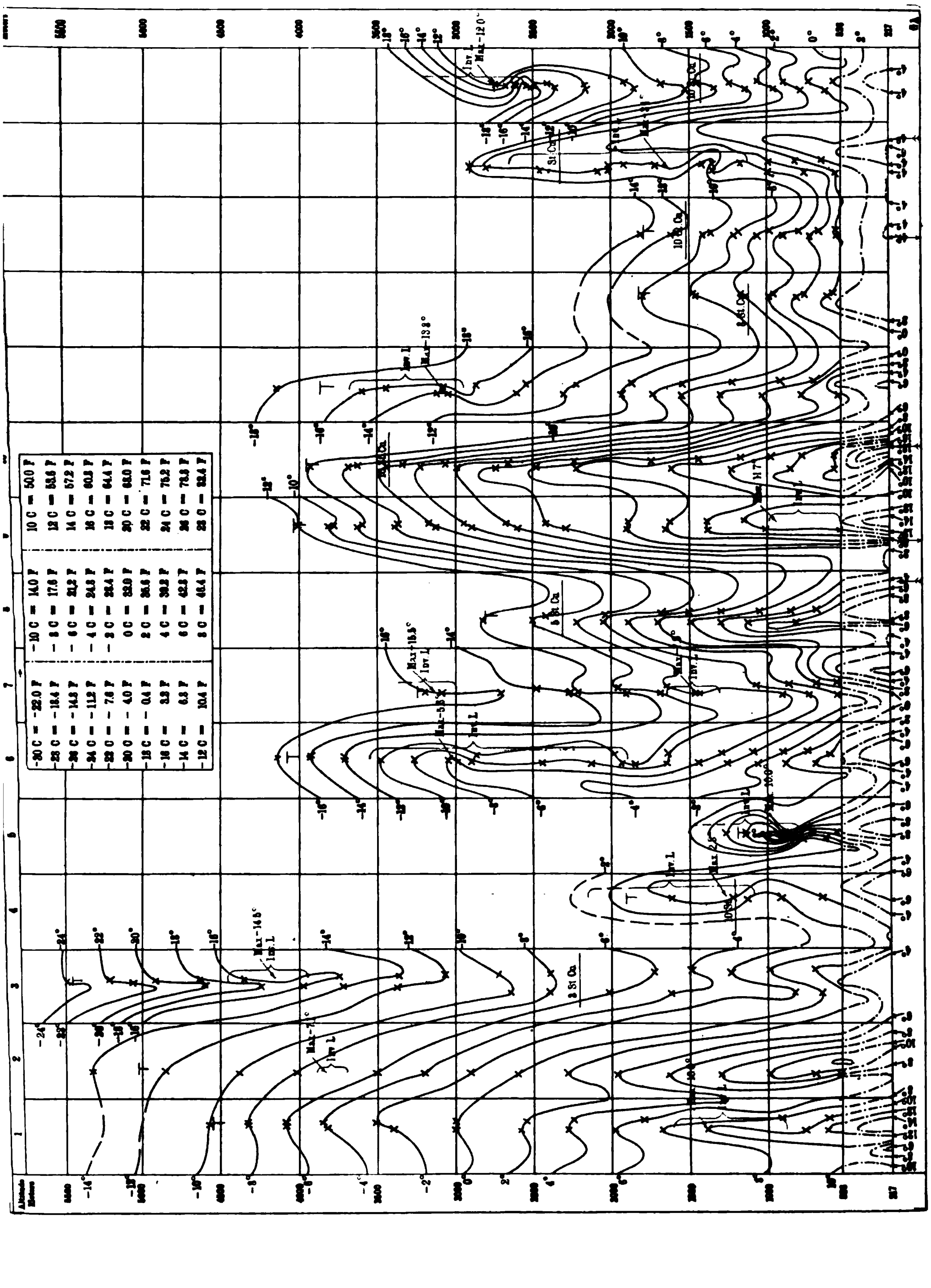


CHART XXI.—Free-air isotherms, November 1-15, 1910.

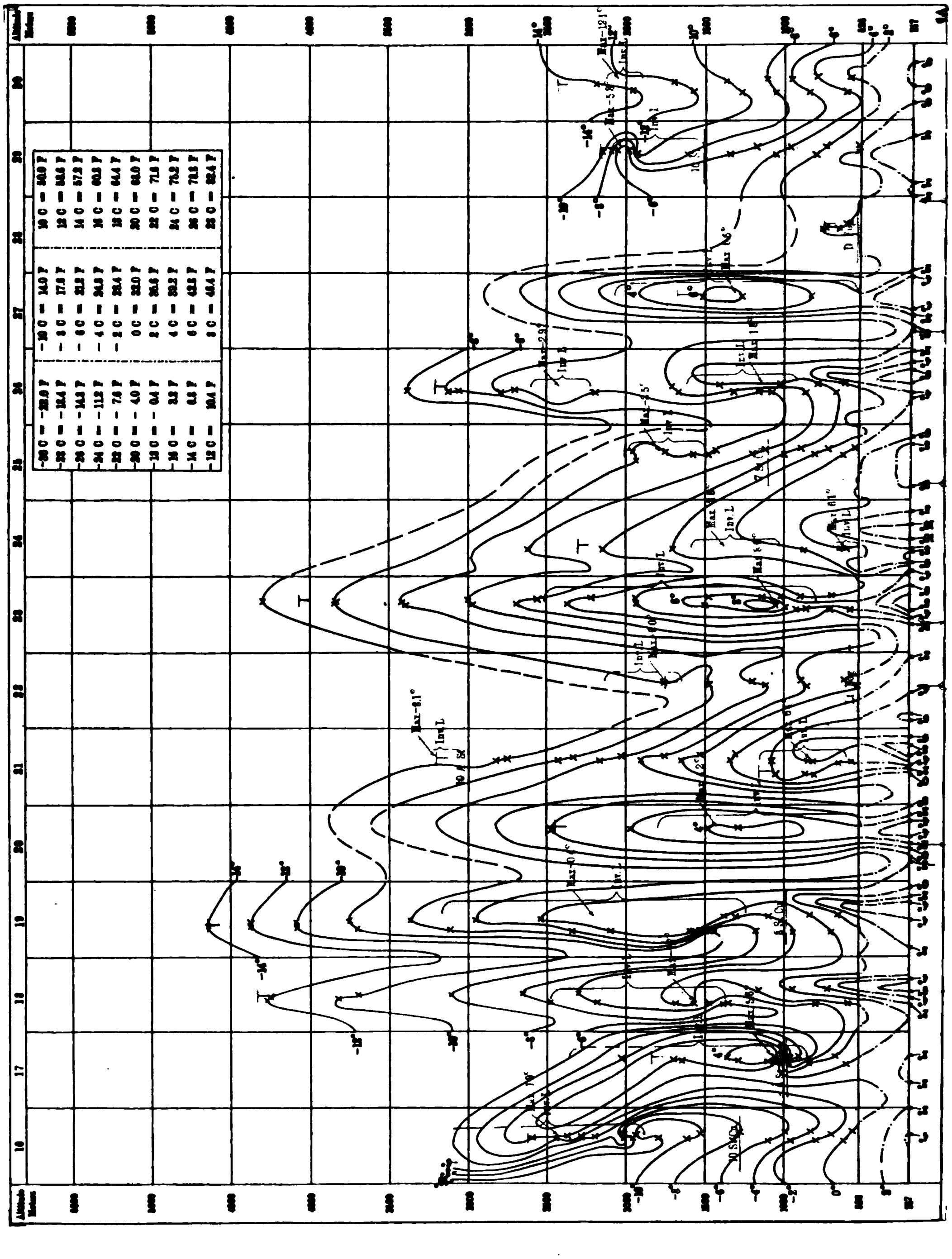


CHART XXII.—Free-air isotherms, November 16-30, 1910.

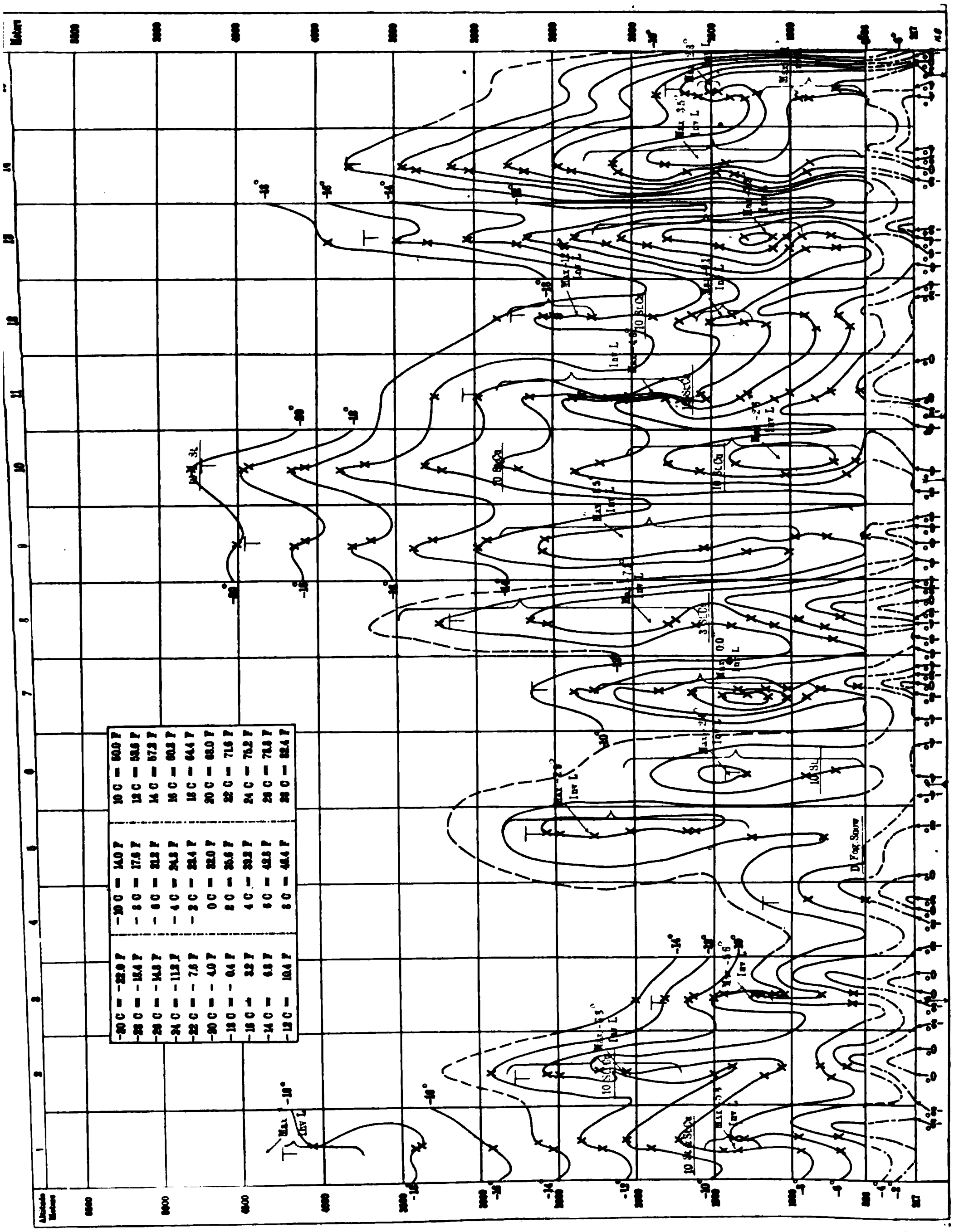


CHART XXIII.—Free-air isotherms, December 1-15, 1910.

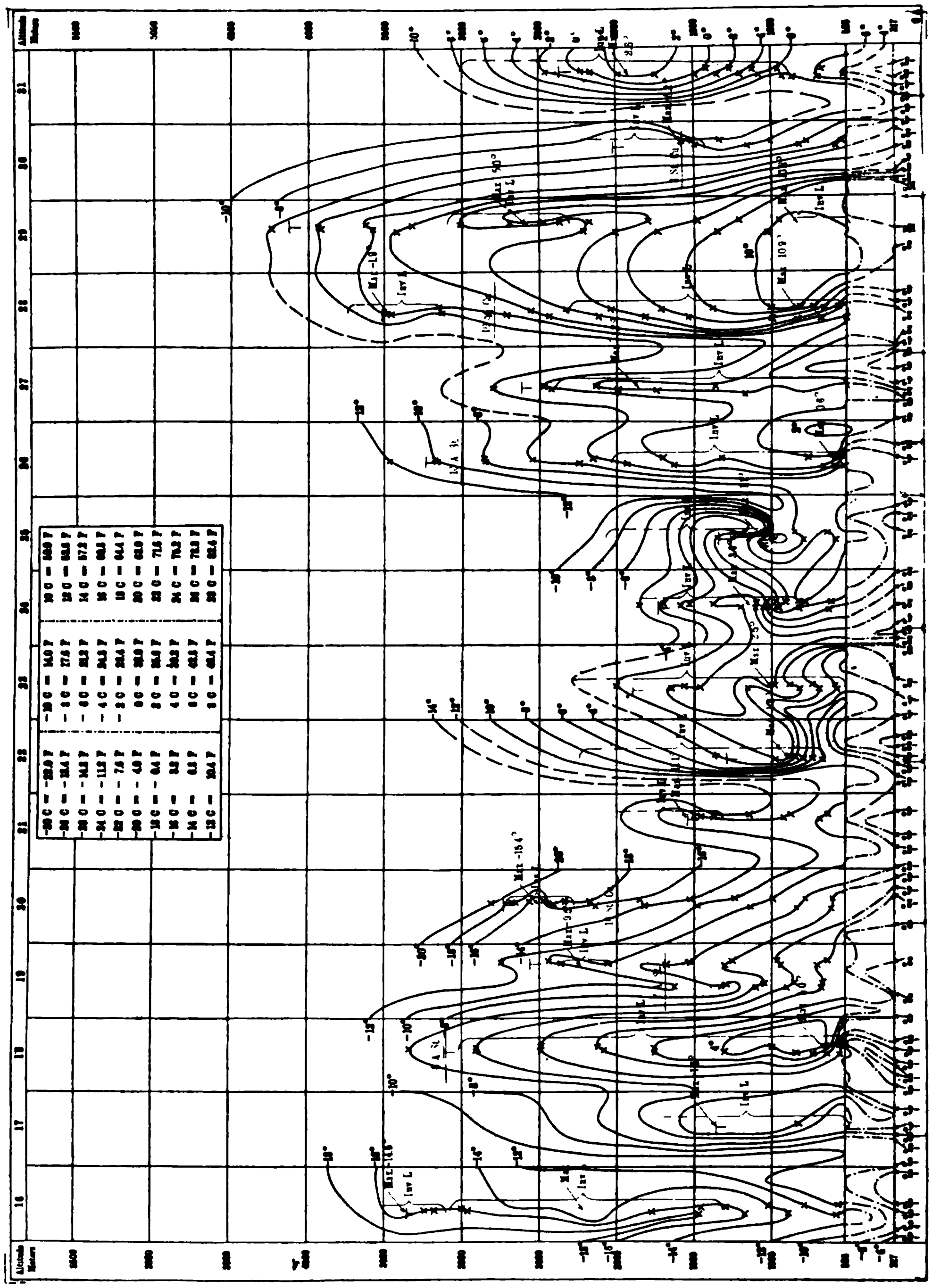


CHART XXIV. —Free-air isotherms, December 16-31, 1910.

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